



# TEF6701HL

## Car radio tuner front-end for digital IF

Rev. 01 — 16 November 2004

Product data sheet

## 1. General description

The TEF6701HL is a single chip car radio tuner for AM, FM standard, FM In-Band On-Channel Digital Audio Broadcast (IBOC DAB) and weather band providing gain controlled output of FM IF and AM IF2 for a car IF DSP IC (e.g. SAA7724H) including the following functions:

- AM double conversion tuner for LW/MW/SW (31 m, 41 m and 49 m bands) with IF1 = 10.7 MHz and IF2 = 450 kHz
- FM single conversion tuner to an IF frequency of 10.7 MHz with integrated image rejection for US FM, Europe FM, Japan FM, East Europe FM and weather band reception; all bands can be selected using high side or low side Local Oscillator (LO) injection
- Tuning system includes VCO, crystal oscillator and PLL synthesizer on one chip.

## 2. Features

- FM mixer for conversion of FM RF (64 MHz to 108 MHz and US weather band) to an IF of 10.7 MHz; the mixer provides inherent image rejection and can be switched from low injection to high injection Local Oscillator (LO) via the I<sup>2</sup>C-bus; two different mixer conversion gains can be selected via the I<sup>2</sup>C-bus
- AGC PIN diode drive circuit for FM RF AGC; AGC detection at FM mixer input; the AGC PIN diode drive can be activated via the I<sup>2</sup>C-bus as a local function for search tuning; AGC threshold is a programmable and keyed function switchable via the I<sup>2</sup>C-bus
- Digital alignment circuit for bus controlled matching of oscillator tuning voltage to FM antenna tank circuit tuning voltage
- Buffer output for weather band flag
- FM IF linear amplifier with high dynamic input range; amplifier gain can be switched to two different positions via the I<sup>2</sup>C-bus
- FM IF AGC with multiplexed inputs for FM and In-Band On-Channel Digital Audio Broadcast (IBOC DAB)
- Buffer amplifier for FM IBOC DAB IF bypassing second IF filter can be activated via I<sup>2</sup>C-bus
- AM mixer 1 for conversion of AM RF to AM IF1 10.7 MHz
- AM RF PIN diode drive circuit and RF JFET conductance control by AGC cascode drive circuit; AGC threshold detection at AM mixer 1 and IF2 AGC input; threshold is programmable via the I<sup>2</sup>C-bus
- AM noise blanker with blanking at AM IF2; AM noise blanker can be deactivated via the I<sup>2</sup>C-bus
- AM mixer 2 for conversion of AM IF1 to AM IF2 450 kHz

# PHILIPS

- AM IF2 AGC
- Multiplexer to output AM IF2 AGC and FM IF AGC to a car IF DSP IC (e.g. SAA7724H)
- AM/FM RF AGC monitor output
- Level detector for AM and FM with temperature compensated output voltage; starting point and slope of level output is programmable via the I<sup>2</sup>C-bus
- IF counter for AM IF2 and FM IF
- LC tuner oscillator providing mixer frequencies for FM mixer and AM mixer 1
- Crystal oscillator providing mixer frequencies for AM mixer 2 and reference for synthesizer PLL, IF count and timing for Radio Data System (RDS) update
- Fast synthesizer PLL tuning system with local control for inaudible RDS updating
- Timing function for RDS update algorithm and control signal output for a car IF DSP IC (e.g. SAA7724H)
- Three hardware programmable I<sup>2</sup>C-bus addresses; pin BUSENABLE; two software controlled flag outputs
- Several test modes for fast IC and system tests.

### 3. Quick reference data

**Table 1: Quick reference data**

| Symbol                                                            | Parameter                                                       | Conditions    | Min   | Typ  | Max    | Unit                         |
|-------------------------------------------------------------------|-----------------------------------------------------------------|---------------|-------|------|--------|------------------------------|
| V <sub>DDA(n)</sub>                                               | analog supply voltages 1 to 4 and 6                             |               | 8     | 8.5  | 9      | V                            |
| V <sub>DDA5</sub>                                                 | analog supply voltage 5                                         |               | 4.75  | 5    | 5.25   | V                            |
| V <sub>DDD</sub>                                                  | digital supply voltage                                          |               | 4.75  | 5    | 5.25   | V                            |
| I <sub>DDA(n)</sub>                                               | sum of analog supply currents 1 to 4 and 6                      | FM Japan mode | 42    | 55   | 71     | mA                           |
|                                                                   |                                                                 | AM mode       | 32    | 43   | 56     | mA                           |
| I <sub>DDA5</sub>                                                 | analog supply current 5                                         | FM Japan mode | 7.5   | 10   | 12     | mA                           |
|                                                                   |                                                                 | AM mode       | 14    | 18.5 | 23     | mA                           |
| I <sub>DDD</sub>                                                  | digital supply current                                          | FM Japan mode | 25    | 32   | 39.5   | mA                           |
|                                                                   |                                                                 | AM mode       | 21    | 26   | 32     | mA                           |
| f <sub>AM(ant)</sub>                                              | AM input frequency                                              | LW            | 0.144 | -    | 0.288  | MHz                          |
|                                                                   |                                                                 | MW            | 0.522 | -    | 1.710  | MHz                          |
|                                                                   |                                                                 | SW            | 5.73  | -    | 9.99   | MHz                          |
| f <sub>FM(ant)</sub>                                              | FM input frequency                                              |               | 64    | -    | 108    | MHz                          |
| f <sub>FM(WB)(ant)</sub>                                          | FM weather band input frequency                                 |               | 162.4 | -    | 162.55 | MHz                          |
| T <sub>amb</sub>                                                  | ambient temperature                                             |               | -40   | -    | +85    | °C                           |
| <b>AM overall system parameters; see <a href="#">Figure 8</a></b> |                                                                 |               |       |      |        |                              |
| g <sub>m(conv)</sub>                                              | AM mixer 1 conversion transconductance $\frac{I_{IF1}}{V_{RF}}$ |               | 3.9   | 5.2  | 6.5    | $\frac{\text{mA}}{\text{V}}$ |
| F <sub>AMMIX1</sub>                                               | noise figure of AM mixer 1                                      |               | -     | 4.5  | 7.1    | dB                           |

Table 1: Quick reference data ...continued

| Symbol                                                     | Parameter                                                                           | Conditions                                                                                 | Min | Typ  | Max | Unit                         |
|------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----|------|-----|------------------------------|
| IP3                                                        | 3rd-order input intercept point                                                     | $R_L = 2.6 \text{ k}\Omega$ (AC load between output pins);<br>$\Delta f = 300 \text{ kHz}$ | 135 | 138  | -   | $\text{dB}\mu\text{V}$       |
| $g_{m(\text{conv})}$                                       | AM mixer 2 conversion transconductance<br>$\frac{I_{\text{IF2}}}{V_{\text{IF1}}}$   |                                                                                            | 3.2 | 4.3  | 5.4 | $\frac{\text{mA}}{\text{V}}$ |
| $\Delta\text{AGC}$                                         | AM IF2 amplifier gain control range $\frac{V_{\text{IFstop}}}{V_{\text{IFstart}}}$  |                                                                                            | 52  | -    | -   | dB                           |
| FM overall system parameters; see <a href="#">Figure 8</a> |                                                                                     |                                                                                            |     |      |     |                              |
| FM mixer                                                   |                                                                                     |                                                                                            |     |      |     |                              |
| $g_{m(\text{conv})}$                                       | conversion                                                                          | MIXGAIN = 0                                                                                | 8.5 | 12.5 | 18  | $\frac{\text{mA}}{\text{V}}$ |
|                                                            | transconductance $\frac{I_{\text{IF}}}{V_{\text{RF}}}$                              | MIXGAIN = 1                                                                                | 17  | 25   | 36  | $\frac{\text{mA}}{\text{V}}$ |
| $F_{\text{FMmixer}}$                                       | noise figure of FM mixer                                                            | MIXGAIN = 0                                                                                | -   | 3.5  | 4.6 | dB                           |
|                                                            |                                                                                     | MIXGAIN = 1                                                                                | -   | 2.4  | -   | dB                           |
| IP3                                                        | 3rd-order input intercept point                                                     | MIXGAIN = 0                                                                                | 113 | 117  | -   | $\text{dB}\mu\text{V}$       |
|                                                            |                                                                                     | MIXGAIN = 1                                                                                | -   | 108  | -   | $\text{dB}\mu\text{V}$       |
| FM amplifier                                               |                                                                                     |                                                                                            |     |      |     |                              |
| $G_{\text{IFAMP}}$                                         | FM IF amplifier gain<br>$\frac{V_{\text{FMIFAMPOUT}}}{V_{\text{IFAMPIN-IFAMPDEC}}}$ | $R_L = 330 \text{ }\Omega$ ;<br>$V_{\text{IFAMPIN-IFAMPDEC}} = 1 \text{ mV}$               |     |      |     |                              |
|                                                            |                                                                                     | IFGAIN = 0                                                                                 | -   | 10.5 | -   | dB                           |
|                                                            |                                                                                     | IFGAIN = 1                                                                                 | -   | 14   | -   | dB                           |
| $G_{\text{IBOCAMP}}$                                       | FM IBOC amplifier gain                                                              | IBOC = 1                                                                                   | -   | 8    | -   | dB                           |
| $\text{IP3}_{\text{IF}}$                                   | 3rd-order input intercept point                                                     | IFGAIN = 0                                                                                 | -   | 123  | -   | $\text{dB}\mu\text{V}$       |
|                                                            |                                                                                     | IFGAIN = 1                                                                                 | -   | 119  | -   | $\text{dB}\mu\text{V}$       |
| $\text{IP3}_{\text{IBOC}}$                                 | 3rd-order input intercept point IBOC mode                                           | IBOC = 1                                                                                   | -   | 123  | -   | $\text{dB}\mu\text{V}$       |
| $F_{\text{IFAMP}}$                                         | noise figure of FM IF amplifier                                                     | IFGAIN = 0                                                                                 | -   | 10   | -   | dB                           |
|                                                            |                                                                                     | IFGAIN = 1                                                                                 | -   | 8.3  | -   | dB                           |
| $F_{\text{IBOCAMP}}$                                       | noise figure of FM IBOC amplifier                                                   | IBOC = 1                                                                                   | -   | 7    | -   | dB                           |
| $\Delta\text{AGC}$                                         | FM IF amplifier gain control range $\frac{V_{\text{IFstop}}}{V_{\text{IFstart}}}$   |                                                                                            | 59  | -    | -   | dB                           |



4. Ordering information

Table 2: Ordering information

| Type number | Package |                                                                        |          |
|-------------|---------|------------------------------------------------------------------------|----------|
|             | Name    | Description                                                            | Version  |
| TEF6701HL   | LQFP64  | plastic low profile quad flat package; 64 leads; body 10 × 10 × 1.4 mm | SOT314-2 |

## 5. Block diagram

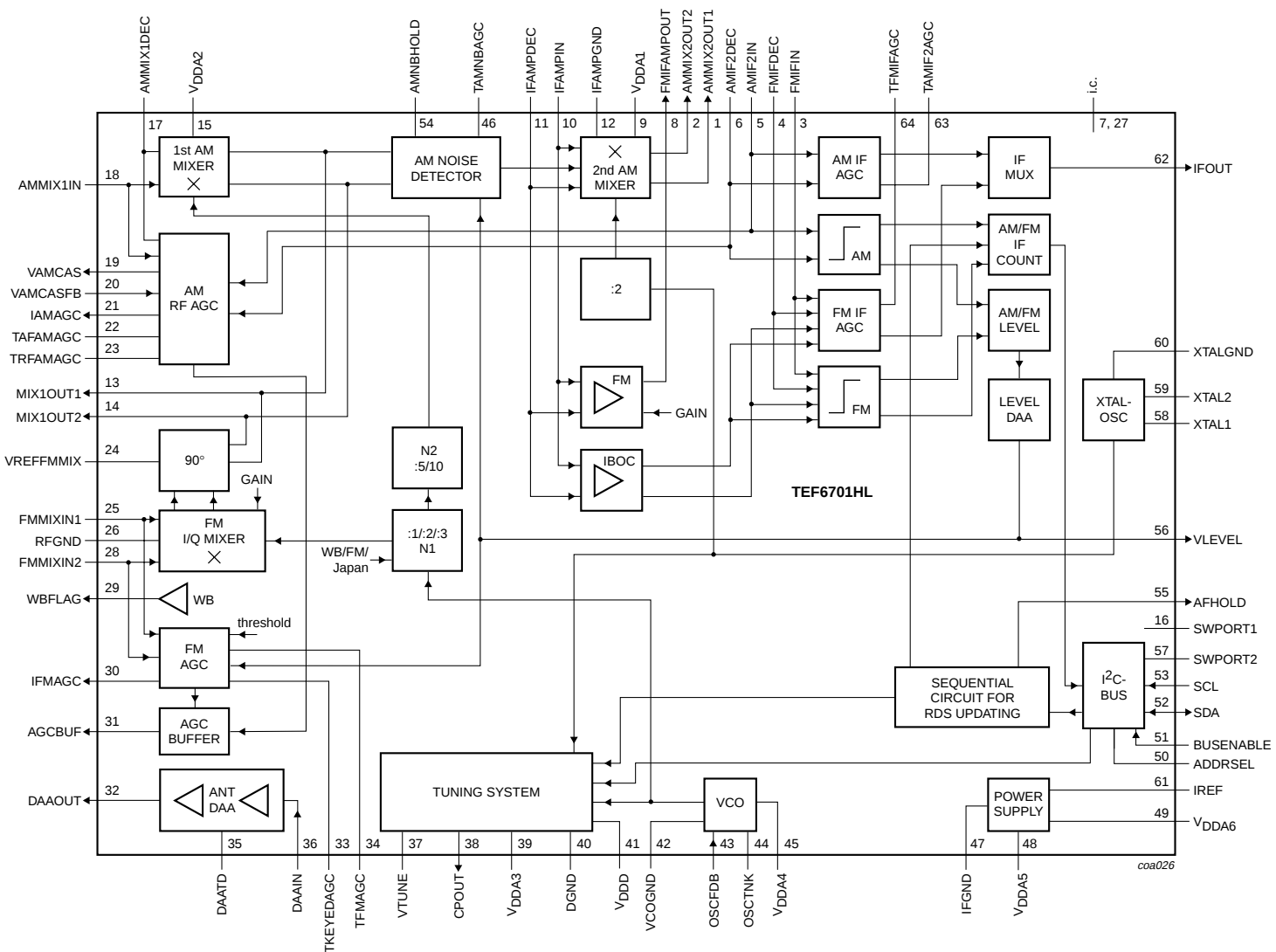
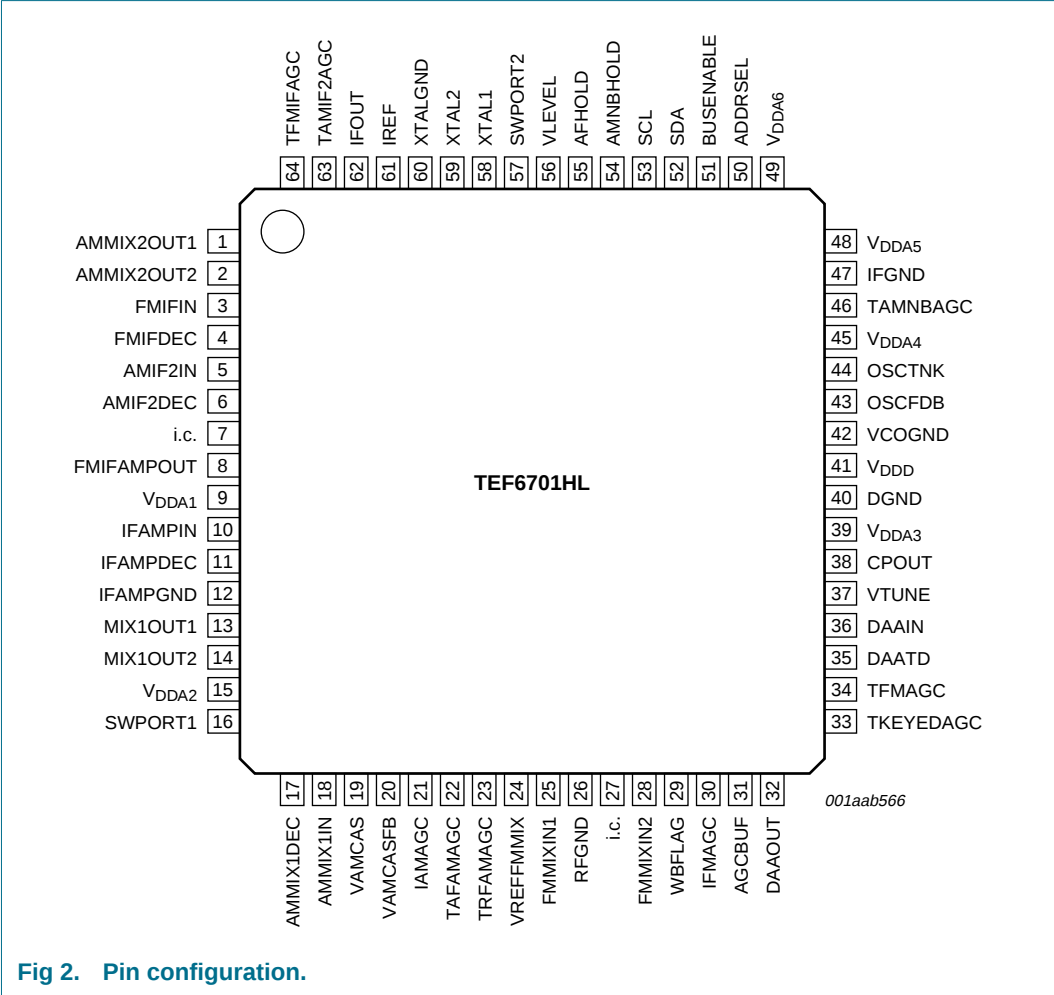


Fig 1. Block diagram.

6. Pinning information

6.1 Pinning



6.2 Pin description

Table 3: Pin description

| Symbol            | Pin | Description                                         |
|-------------------|-----|-----------------------------------------------------|
| AMMIX2OUT1        | 1   | 2nd AM mixer output 1 (450 kHz)                     |
| AMMIX2OUT2        | 2   | 2nd AM mixer output 2 (450 kHz)                     |
| FMIFIN            | 3   | FM IF AGC and FM level detector input               |
| FMIFDEC           | 4   | FM IF AGC and FM level detector decoupling          |
| AMIF2IN           | 5   | AM IF2 AGC and AM level detector input (450 kHz)    |
| AMIF2DEC          | 6   | AM IF2 AGC and AM level detector decoupling         |
| i.c.              | 7   | internally connected                                |
| FMIFAMPOUT        | 8   | FM IF amplifier output (10.7 MHz)                   |
| V <sub>DDA1</sub> | 9   | analog supply voltage 1 (8.5 V) for FM IF amplifier |

Table 3: Pin description ...continued

| Symbol            | Pin | Description                                                                               |
|-------------------|-----|-------------------------------------------------------------------------------------------|
| IFAMPIN           | 10  | FM IF amplifier and AM mixer 2 input (10.7 MHz)                                           |
| IFAMPDEC          | 11  | FM IF amplifier and AM mixer 2 decoupling                                                 |
| IFAMPGND          | 12  | ground for FM IF amplifier                                                                |
| MIX1OUT1          | 13  | FM mixer and AM mixer 1 IF output 1 (10.7 MHz)                                            |
| MIX1OUT2          | 14  | FM mixer and AM mixer 1 IF output 2 (10.7 MHz)                                            |
| V <sub>DDA2</sub> | 15  | analog supply voltage 2 (8.5 V) for FM and AM RF                                          |
| SWPORT1           | 16  | software programmable port 1                                                              |
| AMMIX1DEC         | 17  | AM mixer 1 decoupling                                                                     |
| AMMIX1IN          | 18  | AM mixer 1 input                                                                          |
| VAMCAS            | 19  | output for AM RF cascode AGC                                                              |
| VAMCASFB          | 20  | feedback input for AM RF cascode AGC                                                      |
| IAMAGC            | 21  | PIN diode drive current output of AM front-end AGC                                        |
| TAFAMAGC          | 22  | AF time constant of AM front-end AGC                                                      |
| TRFAMAGC          | 23  | RF time constant of AM front-end AGC                                                      |
| VREFFMMIX         | 24  | reference voltage for FM RF mixer                                                         |
| FMMIXIN1          | 25  | FM mixer input 1                                                                          |
| RFGND             | 26  | RF ground                                                                                 |
| i.c.              | 27  | internally connected                                                                      |
| FMMIXIN2          | 28  | FM mixer input 2                                                                          |
| WBFLAG            | 29  | buffered weather band flag output                                                         |
| IFMAGC            | 30  | PIN diode drive current output of FM front-end AGC                                        |
| AGCBUF            | 31  | monitor current output of FM and AM front-end AGC                                         |
| DAAOUT            | 32  | output of digital auto alignment circuit for antenna tank circuit                         |
| TKEYEDAGC         | 33  | time constant of keyed FM front-end AGC                                                   |
| TFMAGC            | 34  | time constant of FM front-end AGC                                                         |
| DAATD             | 35  | temperature compensation diode of digital auto alignment circuit for antenna tank circuit |
| DAAIN             | 36  | input of digital auto alignment circuit for antenna tank circuit                          |
| VTUNE             | 37  | VCO tuning voltage                                                                        |
| CPOUT             | 38  | charge pump output                                                                        |
| V <sub>DDA3</sub> | 39  | analog supply voltage 3 (8.5 V) for tuning PLL                                            |
| DGND              | 40  | digital ground                                                                            |
| V <sub>DDD</sub>  | 41  | digital supply voltage (5 V)                                                              |
| VCOGND            | 42  | VCO ground                                                                                |
| OSCFDB            | 43  | VCO feedback input                                                                        |
| OSCTNK            | 44  | VCO tank circuit                                                                          |
| V <sub>DDA4</sub> | 45  | analog supply voltage 4 (8.5 V) for VCO                                                   |
| TAMNBAGC          | 46  | AGC time constant for AM IF noise blanker                                                 |
| IFGND             | 47  | IF AGC ground                                                                             |
| V <sub>DDA5</sub> | 48  | analog supply voltage 5 (5 V) for on-chip power supply                                    |
| V <sub>DDA6</sub> | 49  | analog supply voltage 6 (8.5 V) for on-chip power supply                                  |

Table 3: Pin description ...continued

| Symbol    | Pin | Description                                             |
|-----------|-----|---------------------------------------------------------|
| ADDRSEL   | 50  | hardware address select for I <sup>2</sup> C-bus        |
| BUSENABLE | 51  | enable input for I <sup>2</sup> C-bus                   |
| SDA       | 52  | I <sup>2</sup> C-bus data line input and output         |
| SCL       | 53  | I <sup>2</sup> C-bus clock line input                   |
| AMNBHOLD  | 54  | AM noise blanker threshold                              |
| AFHOLD    | 55  | AF hold flag output for a car IF DSP IC (e.g. SAA7724H) |
| VLEVEL    | 56  | level voltage output for AM and FM                      |
| SWPORT2   | 57  | software programmable port 2                            |
| XTAL1     | 58  | crystal oscillator 1                                    |
| XTAL2     | 59  | crystal oscillator 2                                    |
| XTALGND   | 60  | crystal oscillator ground                               |
| IREF      | 61  | reference current for power supply                      |
| IFOUT     | 62  | multiplexer output for FM IF AGC and AM IF2 AGC         |
| TAMIF2AGC | 63  | time constant for AM IF2 AGC                            |
| TFMIFAGC  | 64  | time constant for FM IF AGC                             |

## 7. Functional description

### 7.1 FM I/Q mixer

The FM quadrature mixer converts FM RF (64 MHz to 162.55 MHz) to an IF of 10.7 MHz. The FM mixer provides inherent image rejection and high RF sensitivity. The image rejection can be switched from low injection Local Oscillator (LO) to high injection LO via the I<sup>2</sup>C-bus. The mixer gain can be increased by 6 dB via the I<sup>2</sup>C-bus. In this case the threshold of the FM keyed AGC has to be lowered by 6 dB to prevent the mixer from being overloaded.

The mixer is capable of tuning the:

- US FM and US IBOC DAB from 87.9 MHz to 107.9 MHz
- US weather FM from 162.4 MHz to 162.55 MHz
- Europe FM from 87.5 MHz to 108 MHz
- Japan FM from 76 MHz to 91 MHz
- East Europe FM from 64 MHz to 74 MHz.

### 7.2 Buffer output for weather band flag

The buffer output (pin WBFLAG) is HIGH for weather band mode.

### 7.3 VCO

The varactor tuned LC oscillator provides the local oscillator signal for both FM and AM mixer 1. It has a frequency range from 159.9 MHz to 248.2 MHz.

## 7.4 Crystal oscillator

The crystal oscillator provides a 20.5 MHz signal that is used for:

- Reference frequency for frequency synthesizer PLL
- Local oscillator for AM mixer 2
- Reference frequency for the IF counter
- Timing signal for the RDS update algorithm.

## 7.5 PLL

The fast synthesizer PLL tuning system with local control is used for inaudible RDS updating.

## 7.6 DAA

To reduce the number of manual alignments in production, the following I<sup>2</sup>C-bus controlled Digital Auto Alignment (DAA) functions are included:

- FM RF DAA
  - 7-bit DAA circuitry for the conversion of the VCO tuning voltage to a controlled alignment voltage for the FM antenna tank circuit.
- FM and AM level DAA
  - Level DAA circuitry for alignment of slope (3-bit) and starting point (5-bit) of the level curve.

## 7.7 FM keyed AGC

The AGC threshold is programmable and the keyed AGC function is switchable via the I<sup>2</sup>C-bus. AGC detection occurs at the input of the FM mixer. If the keyed AGC function is activated, the AGC is keyed only by the narrow-band level. The AGC PIN diode drive can be activated via the I<sup>2</sup>C-bus as a local function for search tuning. The AGC sources a constant 10 mA current into the FM PIN diode in AM mode.

## 7.8 FM IF amplifier

The FM IF amplifier provides 10.5 dB or 14 dB gain, selectable via the I<sup>2</sup>C-bus with high linearity over a wide dynamic range. In IBOC DAB mode (activated via the I<sup>2</sup>C-bus) FM IF is buffered and directly fed to FM IF AGC, bypassing the second FM ceramic filter.

## 7.9 FM IF AGC

This is a linear FM IF AGC amplifier with multiplexed inputs for FM standard and FM IBOC DAB. The gain controlled FM IF is output by the multiplexed FM IF/AM IF2 buffer for a car IF DSP IC (e.g. SAA7724H).

## 7.10 AM tuner including mixer 1 and mixer 2

The AM tuner is realized in a double conversion technique and is capable of selecting LW, MW and SW bands.

AM mixer 1 converts AM RF to an IF1 of 10.7 MHz, while AM mixer 2 converts IF1 of 10.7 MHz to an IF2 of 450 kHz:

- LW from 144 kHz to 288 kHz
- MW from 522 kHz to 1710 kHz (US AM band)
- SW from 5.73 MHz to 9.99 MHz (including the 31 m, 41 m and 49 m bands).

### 7.11 AM RF AGC

The AM wideband AGC in front of the AM mixer 1 is realized first by a cascoded NPN transistor, which controls the transconductance of the RF amplifier JFET with 10 dB of AGC range. An AM PIN diode stage with 30 dB of AGC range is also available. The minimum JFET drain source voltage is controlled by a DC feedback loop (pin VAMCASFB) in order to limit the cascode AGC range to 10 dB. If the cascode AGC is not required, a simple RF AGC loop is possible by using only a PIN diode. In some conditions, noise behavior will increase. In this case pins VAMCAS and VAMCASFB have to be left open-circuit. In FM mode, the cascode switches off the JFET bias current to reduce the total power consumption. The PIN diode is biased by 1 mA in FM mode.

The AGC detection points for AM RF AGC are at the AM mixer 1 input (threshold programmable via the I<sup>2</sup>C-bus) and the IF2 AGC input (fixed threshold).

### 7.12 AM noise blanker

The detection point for the AM noise blanker is the output stage of AM mixer 1, while blanking is realized at the output of mixer 2.

### 7.13 AM IF2 AGC

This is a linear AM IF2 AGC amplifier. The gain controlled AM IF2 is output via the multiplexed FM IF/AM IF2 buffer to a car IF DSP IC (e.g. SAA7724H).

### 7.14 FM IF and AM IF2 buffer

This buffers and multiplexes AM IF2 and FM IF to pin IFOUT.

### 7.15 FM and AM level detector

The FM and AM level detectors provide the temperature compensated output voltage. The starting points and slopes of the level detector outputs are programmable via the I<sup>2</sup>C-bus.

### 7.16 FM/AM RF AGC buffer

The output (open-collector) sinks a current which in AM mode is proportional to the voltage at pin TRFAMAGC and in FM mode proportional to the RF level detector voltage (pin TFMAGC) inside the FM AGC.

## 8. I<sup>2</sup>C-bus protocol

### 8.1 I<sup>2</sup>C-bus specification

SDA and SCL HIGH and LOW levels are specified according to a 3.3 V I<sup>2</sup>C-bus. The bus pins tolerate also thresholds of a 5 V bus.

The standard I<sup>2</sup>C-bus specification is expanded by the following definitions.

IC addresses:

- 1st IC address C2H: 1100001 R/ $\overline{W}$
- 2nd IC address C0H: 1100000 R/ $\overline{W}$
- 3rd IC address C4H: 1100010 R/ $\overline{W}$ .

Structure of the I<sup>2</sup>C-bus logic: slave transceiver with auto increment.

Subaddresses are not used.

The second I<sup>2</sup>C-bus address can be selected by connecting pin ADDRSEL via a 120 k $\Omega$  resistor to GND. The third I<sup>2</sup>C-bus address can be selected by connecting pin ADDRSEL via a 33 k $\Omega$  resistor to GND.

The maximum bit rate for this device is 100 kbit/s.

The I<sup>2</sup>C-bus interface is extended with an enable input (pin BUSENABLE). If pin BUSENABLE is HIGH the communication with the device is active; if pin BUSENABLE is LOW the signals on the I<sup>2</sup>C-bus are ignored so that higher bit rates (> 100 kbit/s) can be used to communicate with other devices on the same I<sup>2</sup>C-bus. The enable signal must not change while bus communication takes place.

The data hold time  $t_{HD;DAT}$  must be at least 1  $\mu$ s.

**No default settings at power-on reset.** I<sup>2</sup>C-bus transmission is required to program the IC.

#### 8.1.1 Data transfer

Data sequence: address, byte 0, byte 1, byte 2, byte 3, byte 4, byte 5 and byte 6.

The data transfer has to be in this order. The LSB of the address being logic 0 indicates a write operation.

Bit 7 of each byte is considered the MSB and has to be transferred as the first bit of the byte.

The data becomes valid at the output of the internal latches with the acknowledge of each byte. A STOP condition after any byte can shorten transmission times.

When writing to the transceiver by using the STOP condition before completion of the whole transfer:

- The remaining bytes will contain the old information
- If the transfer of a byte is not completed, this byte is lost and the previous information is available.

### 8.1.2 Frequency setting

For new frequency setting, in both AM and FM mode, the programmable divider is enabled by setting bit PRESET to logic 1. To select a frequency, two I<sup>2</sup>C-bus transmissions are necessary:

- First: bit PRESET = 1
- Second: bit PRESET = 0.

### 8.1.3 Restriction of the I<sup>2</sup>C-bus characteristic

At –40 °C the start of the acknowledge bit after transmitting the slave address exceeds the general requirement of  $t_{HD;DAT} < 3.45 \mu s$ . The start of acknowledge is  $t_{ST;ACK} < 4.1 \mu s$  over the full temperature range from –40 °C to +85 °C. This will not influence the overall system performance, because the required set-up time  $t_{SU;DAT} > 250 ns$  is fulfilled at any condition.

## 8.2 I<sup>2</sup>C-bus protocol

### 8.2.1 Data transfer mode and IC address

Table 4: Write mode

|       |                 |       |              |       |       |
|-------|-----------------|-------|--------------|-------|-------|
| S [1] | address (write) | A [2] | data byte(s) | A [2] | P [3] |
|-------|-----------------|-------|--------------|-------|-------|

[1] S = START condition.

[2] A = acknowledge.

[3] P = STOP condition.

Table 5: Read mode

|       |                |       |             |        |       |
|-------|----------------|-------|-------------|--------|-------|
| S [1] | address (read) | A [2] | data byte 0 | NA [3] | P [4] |
|-------|----------------|-------|-------------|--------|-------|

[1] S = START condition.

[2] A = acknowledge.

[3] NA = no acknowledge.

[4] P = STOP condition.

Table 6: IC address byte

| Address | IC address [1] |   |   |   |   |   |   | Mode [2]         |
|---------|----------------|---|---|---|---|---|---|------------------|
| 1       | 1              | 1 | 0 | 0 | 0 | 0 | 1 | R $\overline{W}$ |
| 2       | 1              | 1 | 0 | 0 | 0 | 0 | 0 | R $\overline{W}$ |
| 3       | 1              | 1 | 0 | 0 | 0 | 1 | 0 | R $\overline{W}$ |

[1] Pin ADDRSEL left open-circuit activates first IC address;  $R_{ext} = 120 k\Omega$  at pin ADDRSEL to ground activates second IC address;  $R_{ext} = 33 k\Omega$  at pin ADDRSEL to ground activates third IC address.

[2] Read or write bit:

0 = write operation to TEF6701HL

1 = read operation from TEF6701HL.

## 8.2.2 Write mode: data byte 0

Table 7: Format of data byte 0

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| AF    | PLL14 | PLL13 | PLL12 | PLL11 | PLL10 | PLL9  | PLL8  |

Table 8: Description of data byte 0 bits

| Bit    | Symbol    | Description                                                                                           |
|--------|-----------|-------------------------------------------------------------------------------------------------------|
| 7      | AF        | <b>Alternative frequency.</b> If AF = 0, then normal operation. If AF = 1, then AF (RDS) update mode. |
| 6 to 0 | PLL[14:8] | <b>Setting of programmable counter of synthesizer PLL.</b> Upper byte of PLL divider word.            |

## 8.2.3 Write mode: data byte 1

Table 9: Format of data byte 1

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| PLL7  | PLL6  | PLL5  | PLL4  | PLL3  | PLL2  | PLL1  | PLL0  |

Table 10: Description of data byte 1 bits

| Bit    | Symbol   | Description                                                                                |
|--------|----------|--------------------------------------------------------------------------------------------|
| 7 to 0 | PLL[7:0] | <b>Setting of programmable counter of synthesizer PLL.</b> Lower byte of PLL divider word. |

## 8.2.4 Write mode: data byte 2

Table 11: Format of data byte 2

| Bit 7  | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|-------|-------|-------|-------|-------|-------|-------|
| PRESET | DAA6  | DAA5  | DAA4  | DAA3  | DAA2  | DAA1  | DAA0  |

Table 12: Description of data byte 2 bits

| Bit    | Symbol   | Description                                                                                                                                                  |
|--------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7      | PRESET   | <b>Preset.</b> If PRESET = 0, then programmable divider and antenna DAA locked. If PRESET = 1, then writing to programmable divider and antenna DAA enabled. |
| 6 to 0 | DAA[6:0] | <b>Setting of antenna digital auto alignment.</b>                                                                                                            |

## 8.2.5 Write mode: data byte 3

Table 13: Format of data byte 3

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| IFMT  | FREF2 | FREF1 | FREF0 | IFPR  | BND1  | BND0  | AMFM  |

Table 14: Description of data byte 3 bits

| Bit     | Symbol    | Description                                                                                                                          |
|---------|-----------|--------------------------------------------------------------------------------------------------------------------------------------|
| 7       | IFMT      | <b>IF measuring time.</b> If IFMT = 0, then IF measuring time is 20 ms. If IFMT = 1, then IF measuring time is 2 ms.                 |
| 6 to 4  | FREF[2:0] | <b>Reference frequency for synthesizer.</b> These 3 bits determine the reference frequency, see <a href="#">Table 15</a> .           |
| 3       | IFPR      | <b>IF counter prescaler ratio.</b> If IFPR = 0, then IF prescaler ratio is 100. If IFPR = 1, then IF prescaler ratio is 10.          |
| 2 and 1 | BND[1:0]  | <b>Band switch.</b> These 2 bits select the frequency in AM and FM mode, see <a href="#">Table 16</a> and <a href="#">Table 17</a> . |
| 0       | AMFM      | <b>AM or FM switch.</b> If AMFM = 0, then FM mode. If AMFM = 1, then AM mode.                                                        |

Table 15: Reference frequency setting

| FREF2 | FREF1 | FREF0 | f <sub>ref</sub> (kHz) |
|-------|-------|-------|------------------------|
| 0     | 0     | 0     | 100                    |
| 1     | 0     | 0     | 50                     |
| 0     | 1     | 0     | 25                     |
| 1     | 1     | 0     | 20                     |
| 0     | 0     | 1     | 10                     |
| 1     | 0     | 1     | 10                     |
| 0     | 1     | 1     | 10                     |
| 1     | 1     | 1     | 10                     |

Table 16: FM band selection bits

| BND1 | BND0 | Frequency band | VCO divider | Charge pump current |
|------|------|----------------|-------------|---------------------|
| 0    | 0    | FM standard    | 2           | 130 $\mu$ A + 3 mA  |
| 0    | 1    | FM Japan       | 3           | 130 $\mu$ A + 3 mA  |
| 1    | 0    | FM East Europe | 3           | 1 mA                |
| 1    | 1    | FM weather     | 1           | 300 $\mu$ A         |

Table 17: AM band selection bits <sup>[1]</sup>

| BND1 | BND0 | Frequency band | VCO divider | Charge pump current |
|------|------|----------------|-------------|---------------------|
| 0    | X    | AM SW          | 10          | 1 mA                |
| 1    | X    | AM LW/MW       | 20          | 1 mA                |

[1] X = don't care.

## 8.2.6 Write mode: data byte 4

Table 18: Format of data byte 4

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1  | Bit 0   |
|-------|-------|-------|-------|-------|-------|--------|---------|
| KAGC  | AGC1  | AGC0  | LODX  | FMINJ | IBOC  | IFGAIN | MIXGAIN |

Table 19: Description of data byte 4 bits

| Bit     | Symbol   | Description                                                                                                                                            |
|---------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7       | KAGC     | <b>Keyed FM AGC.</b> If KAGC = 0, then keyed FM AGC is off. If KAGC = 1, then keyed FM AGC is on.                                                      |
| 6 and 5 | AGC[1:0] | <b>Wideband AGC.</b> These 2 bits set the start value of wideband AGC. For AM, see <a href="#">Table 20</a> and for FM, see <a href="#">Table 21</a> . |
| 4       | LODX     | <b>Local or distance.</b> If LODX = 0, then distance mode is on. If LODX = 1, then local mode is on.                                                   |
| 3       | FMINJ    | <b>FM mixer image rejection.</b> If FMINJ = 0, then low injection. If FMINJ = 1, then high injection.                                                  |
| 2       | IBOC     | <b>FM IBOC mode.</b> If IBOC = 0, then IBOC buffer amplifier is off. If IBOC = 1, then IBOC buffer amplifier is on.                                    |
| 1       | IFGAIN   | <b>IF amplifier gain.</b> If IFGAIN = 0, then $G_{IFAMP} = 10.5$ dB. If IFGAIN = 1, then $G_{IFAMP} = 14$ dB.                                          |
| 0       | MIXGAIN  | <b>FM mixer gain.</b> If MIXGAIN = 0, then the FM mixer gain is nominal. If MIXGAIN = 1, then the FM mixer gain is +6 dB.                              |

Table 20: Setting of wideband AGC for AM ( $m = 0.3$ )

| AGC1 | AGC0 | AM mixer 1 input voltage (peak value) (mV) |
|------|------|--------------------------------------------|
| 0    | 0    | 530                                        |
| 0    | 1    | 420                                        |
| 1    | 0    | 290                                        |
| 1    | 1    | 150                                        |

Table 21: Setting of wideband AGC for FM

| AGC1 | AGC0 | FM RF mixer input voltage (RMS value) (mV) |
|------|------|--------------------------------------------|
| 1    | 1    | 3                                          |
| 1    | 0    | 6                                          |
| 0    | 1    | 9                                          |
| 0    | 0    | 12                                         |

### 8.2.7 Write mode: data byte 5

Table 22: Format of data byte 5

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| LST4  | LST3  | LST2  | LST1  | LST0  | LSL2  | LSL1  | LSL0  |

Table 23: Description of data byte 5 bits

| Bit    | Symbol   | Description                                                                                                         |
|--------|----------|---------------------------------------------------------------------------------------------------------------------|
| 7 to 3 | LST[4:0] | <b>Setting of level DAA starting point.</b> These 5 bits determine the offset of the level detector output voltage. |
| 2 to 0 | LSL[2:0] | <b>Setting of level DAA slope.</b> These 3 bits determine the steepness of the level detector output voltage.       |

Table 24: Standard setting of data byte 5 bits

| Setting of level DAA starting point |      |      |      |      | Setting of level DAA slope |      |      |
|-------------------------------------|------|------|------|------|----------------------------|------|------|
| LST4                                | LST3 | LST2 | LST1 | LST0 | LSL2                       | LSL1 | LSL0 |
| 1                                   | 0    | 0    | 0    | 0    | 1                          | 0    | 0    |

### 8.2.8 Write mode: data byte 6

Table 25: Format of data byte 6

| Bit 7   | Bit 6   | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|---------|-------|-------|-------|-------|-------|-------|
| SWPORT2 | SWPORT1 | AMNB  | -     | -     | -     | -     | -     |

Table 26: Description of data byte 6 bits

| Bit    | Symbol  | Description                                                                                                                                                           |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7      | SWPORT2 | <b>Software programmable port 2.</b> If SWPORT2 = 0, then pin SWPORT2 is inactive (high-impedance). If SWPORT2 = 1, then pin SWPORT2 is active (pull down to ground). |
| 6      | SWPORT1 | <b>Software programmable port 1.</b> If SWPORT1 = 0, then pin SWPORT1 is inactive (high-impedance). If SWPORT1 = 1, then pin SWPORT1 is active (pull down to ground). |
| 5      | AMNB    | <b>AM noise blanker.</b> If AMNB = 0, then the AM noise blanker is off. If AMNB = 1, then the AM noise blanker is on.                                                 |
| 4 to 0 | -       | These 5 bits are not used and should be set to logic 0.                                                                                                               |

### 8.2.9 Read mode: data byte 0

Table 27: Format of first data byte

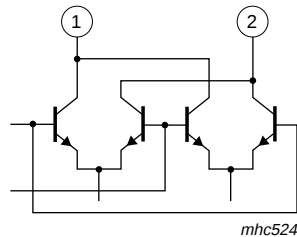
| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| IFC7  | IFC6  | IFC5  | IFC4  | IFC3  | IFC2  | IFC1  | IFC0  |

Table 28: Description of data byte 0 bits

| Bit    | Symbol   | Description                                                                                             |
|--------|----------|---------------------------------------------------------------------------------------------------------|
| 7 to 0 | IFC[7:0] | <b>IF counter result.</b> These bits contain the least significant eight bits of the IF counter result. |

## 9. Internal circuitry

Table 29: Equivalent pin circuits

| Symbol     | Pin | Equivalent circuit                                                                   |
|------------|-----|--------------------------------------------------------------------------------------|
| AMMIX2OUT1 | 1   |  |
| AMMIX2OUT2 | 2   |                                                                                      |

mhc524

Table 29: Equivalent pin circuits ...continued

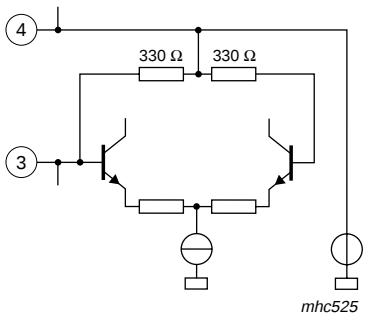
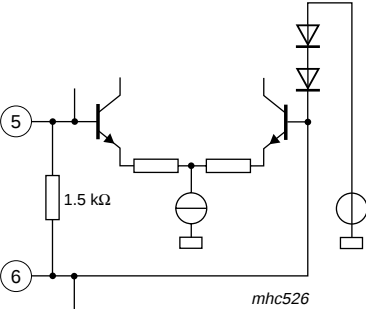
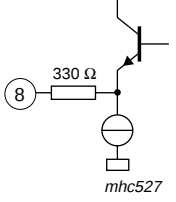
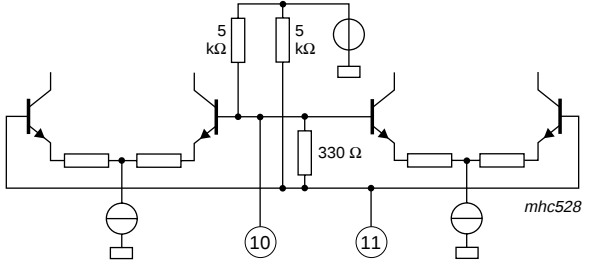
| Symbol             | Pin | Equivalent circuit                                                                    |
|--------------------|-----|---------------------------------------------------------------------------------------|
| FMIFIN             | 3   |     |
| FMIFDEC            | 4   |                                                                                       |
| AMIF2IN            | 5   |    |
| AMIF2DEC           | 6   |                                                                                       |
| i.c.               | 7   |  |
| FMIFAMPOUT         | 8   |                                                                                       |
| V <sub>D</sub> DA1 | 9   |   |
| IFAMPIN            | 10  |                                                                                       |
| IFAMPDEC           | 11  |                                                                                       |
| IFAMPGND           | 12  |                                                                                       |

Table 29: Equivalent pin circuits ...continued

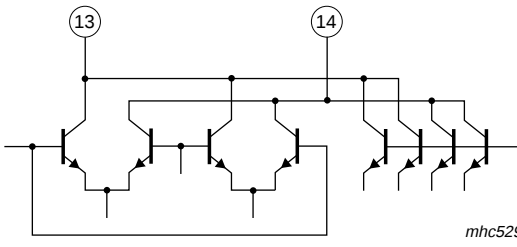
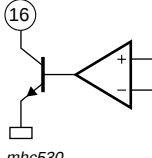
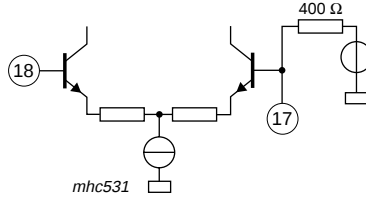
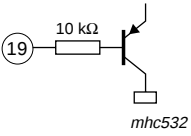
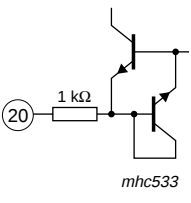
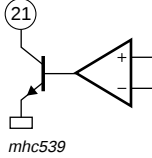
| Symbol            | Pin | Equivalent circuit                                                                                     |
|-------------------|-----|--------------------------------------------------------------------------------------------------------|
| MIX1OUT1          | 13  | <br><i>mhc529</i>    |
| MIX1OUT2          | 14  |                                                                                                        |
| V <sub>DDA2</sub> | 15  | <br><i>mhc530</i>   |
| SWPORT1           | 16  |                                                                                                        |
| AMMIX1DEC         | 17  | <br><i>mhc531</i>   |
| AMMIX1IN          | 18  |                                                                                                        |
| VAMCAS            | 19  | <br><i>mhc532</i> |
| VAMCASFB          | 20  | <br><i>mhc533</i> |
| IAMAGC            | 21  | <br><i>mhc539</i> |

Table 29: Equivalent pin circuits ...continued

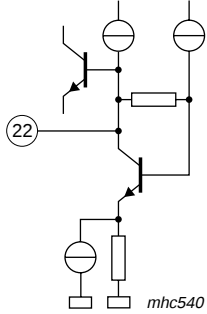
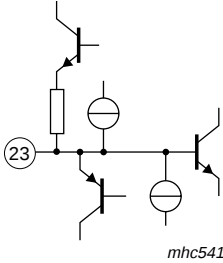
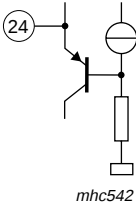
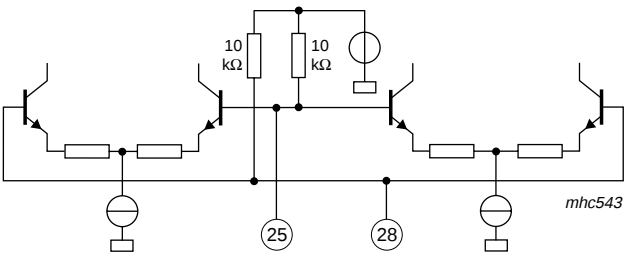
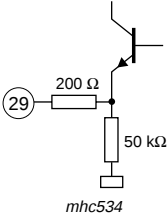
| Symbol    | Pin | Equivalent circuit                                                                    |
|-----------|-----|---------------------------------------------------------------------------------------|
| TAFAMAGC  | 22  |    |
| TRFAMAGC  | 23  |    |
| VREFFMMIX | 24  |  |
| FMMIXIN1  | 25  |   |
| FMMIXIN2  | 28  |                                                                                       |
| RFGND     | 26  |                                                                                       |
| i.c.      | 27  |                                                                                       |
| WBFLAG    | 29  |  |

Table 29: Equivalent pin circuits ...continued

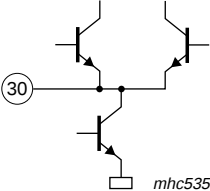
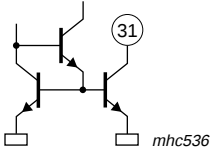
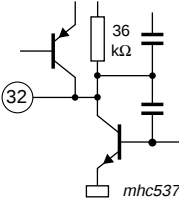
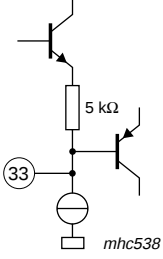
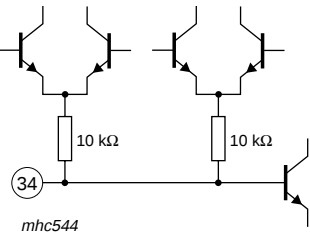
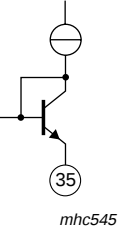
| Symbol    | Pin | Equivalent circuit                                                                    |
|-----------|-----|---------------------------------------------------------------------------------------|
| IFMAGC    | 30  |    |
| AGCBUF    | 31  |    |
| DAAOUT    | 32  |   |
| TKEYEDAGC | 33  |  |
| TFMAGC    | 34  |   |
| DAATD     | 35  |  |

Table 29: Equivalent pin circuits ...continued

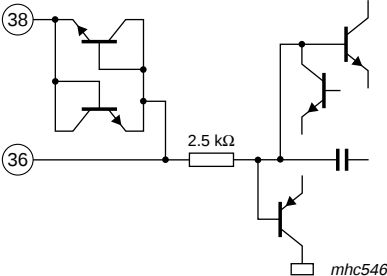
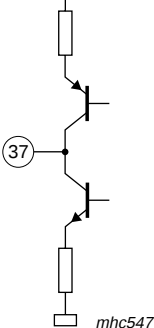
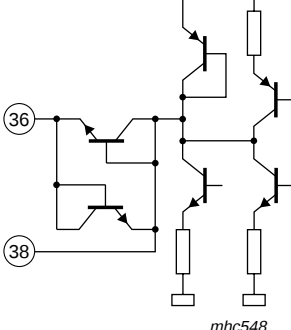
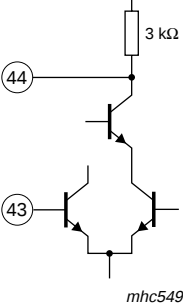
| Symbol             | Pin | Equivalent circuit                                                                    |
|--------------------|-----|---------------------------------------------------------------------------------------|
| DAAIN              | 36  |     |
| VTUNE              | 37  |   |
| CPOUT              | 38  |   |
| V <sub>D</sub> DA3 | 39  |                                                                                       |
| DGND               | 40  |                                                                                       |
| V <sub>D</sub> DD  | 41  |                                                                                       |
| VCOGND             | 42  |                                                                                       |
| OSCFDB             | 43  |                                                                                       |
| OSCTNK             | 44  |  |

Table 29: Equivalent pin circuits ...continued

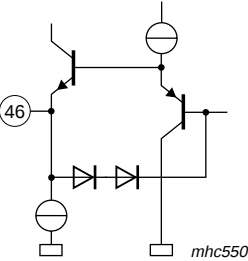
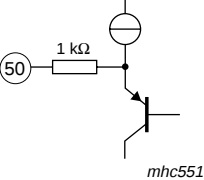
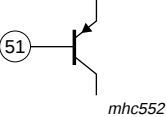
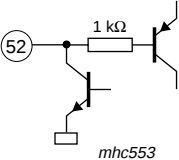
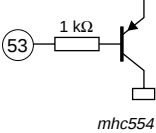
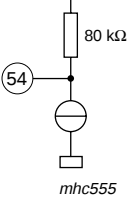
| Symbol             | Pin | Equivalent circuit                                                                    |
|--------------------|-----|---------------------------------------------------------------------------------------|
| V <sub>D</sub> DA4 | 45  |                                                                                       |
| TAMNBAGC           | 46  |     |
| IFGND              | 47  |                                                                                       |
| V <sub>D</sub> DA5 | 48  |                                                                                       |
| V <sub>D</sub> DA6 | 49  |                                                                                       |
| ADDRSEL            | 50  |   |
| BUSENABLE          | 51  |  |
| SDA                | 52  |  |
| SCL                | 53  |  |
| AMNBHOLD           | 54  |  |

Table 29: Equivalent pin circuits ...continued

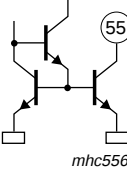
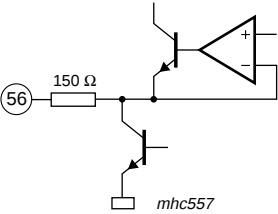
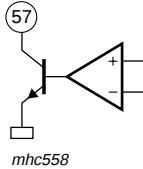
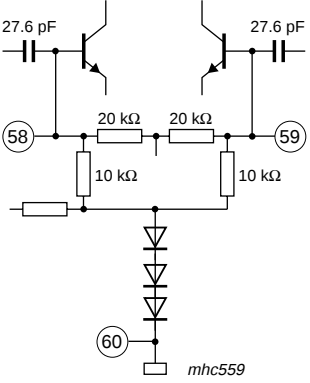
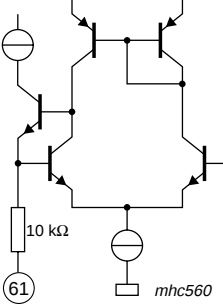
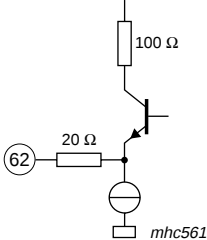
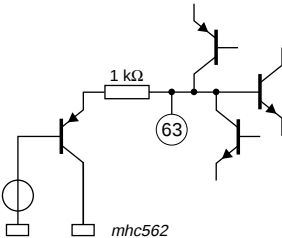
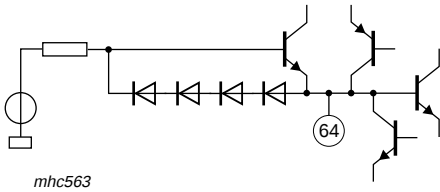
| Symbol  | Pin | Equivalent circuit                                                                   |
|---------|-----|--------------------------------------------------------------------------------------|
| AFHOLD  | 55  |   |
| VLEVEL  | 56  |    |
| SWPORT2 | 57  |  |
| XTAL1   | 58  |  |
| XTAL2   | 59  |                                                                                      |
| XTALGND | 60  |                                                                                      |
| IREF    | 61  |  |

Table 29: Equivalent pin circuits ...continued

| Symbol    | Pin | Equivalent circuit                                                                   |
|-----------|-----|--------------------------------------------------------------------------------------|
| IFOUT     | 62  |   |
| TAMIF2AGC | 63  |    |
| TFMIFAGC  | 64  |  |

## 10. Limiting values

**Table 30: Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol            | Parameter                                        | Conditions | Min                  | Max   | Unit |
|-------------------|--------------------------------------------------|------------|----------------------|-------|------|
| V <sub>DDA1</sub> | analog supply voltage 1 for FM IF amplifier      |            | <sup>[1]</sup> -0.3  | +10   | V    |
| V <sub>DDA2</sub> | analog supply voltage 2 for FM and AM RF         |            | <sup>[1]</sup> -0.3  | +10   | V    |
| V <sub>DDA3</sub> | analog supply voltage 3 for tuning PLL           |            | <sup>[1]</sup> -0.3  | +10   | V    |
| V <sub>DDA4</sub> | analog supply voltage 4 for VCO                  |            | <sup>[1]</sup> -0.3  | +10   | V    |
| V <sub>DDA5</sub> | analog supply voltage 5 for on-chip power supply |            | -0.3                 | +6.5  | V    |
| V <sub>DDA6</sub> | analog supply voltage 6 for on-chip power supply |            | <sup>[1]</sup> -0.3  | +10   | V    |
| V <sub>DD</sub>   | digital supply voltage                           |            | -0.3                 | +6.5  | V    |
| T <sub>stg</sub>  | storage temperature                              |            | -55                  | +150  | °C   |
| T <sub>amb</sub>  | ambient temperature                              |            | -40                  | +85   | °C   |
| V <sub>es</sub>   | electrostatic handling voltage                   |            | <sup>[2]</sup> -200  | +200  | V    |
|                   |                                                  |            | <sup>[3]</sup> -2000 | +2000 | V    |

[1] To avoid damages and wrong operation it is necessary to keep all 8.5 V supply voltages at a higher level than any 5 V supply voltage. This is also necessary during power-on and power-down sequences. Precautions have to be provided in such a way that interferences can not pull down the 8.5 V supply below the 5 V supply.

[2] Machine model (R = 0 Ω, C = 200 pF).

[3] Human body model (R = 1.5 kΩ, C = 100 pF).

## 11. Thermal characteristics

**Table 31: Thermal characteristics**

| Symbol               | Parameter                                   | Conditions  | Typ | Unit |
|----------------------|---------------------------------------------|-------------|-----|------|
| R <sub>th(j-a)</sub> | thermal resistance from junction to ambient | in free air | 58  | K/W  |

## 12. Static characteristics

**Table 32: Static characteristics**

V<sub>DDA1</sub> = V<sub>DDA2</sub> = V<sub>DDA3</sub> = V<sub>DDA4</sub> = V<sub>DDA6</sub> = 8.5 V; V<sub>DDA5</sub> = 5 V; V<sub>DD</sub> = 5 V; T<sub>amb</sub> = 25 °C; unless otherwise specified.

| Symbol                           | Parameter                                   | Conditions   | Min  | Typ | Max  | Unit |
|----------------------------------|---------------------------------------------|--------------|------|-----|------|------|
| <b>Supply voltage</b>            |                                             |              |      |     |      |      |
| V <sub>DDA(n)</sub>              | analog supply voltages 1 to 4 and 6         |              | 8    | 8.5 | 9    | V    |
| V <sub>DDA5</sub>                | analog supply voltage 5                     |              | 4.75 | 5   | 5.25 | V    |
| V <sub>DD</sub>                  | digital supply voltage                      |              | 4.75 | 5   | 5.25 | V    |
| <b>Supply current in FM mode</b> |                                             |              |      |     |      |      |
| I <sub>DDA1</sub>                | analog supply current 1 for FM IF amplifier | IBOC mode    | -    | 7.9 | -    | mA   |
|                                  |                                             | no IBOC mode | -    | 8.9 | -    | mA   |
| I <sub>DDA2</sub>                | analog supply current 2 for RF              |              | 4.7  | 5.7 | 6.7  | mA   |
| I <sub>DDA3</sub>                | analog supply current 3 for tuning PLL      |              | -    | 4   | -    | mA   |
| I <sub>DDA4</sub>                | analog supply current 4 for VCO             |              | 5.2  | 6.5 | 7.8  | mA   |

**Table 32: Static characteristics ...continued**

$V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5\text{ V}$ ;  $V_{DDA5} = 5\text{ V}$ ;  $V_{DDD} = 5\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol                                                            | Parameter                                        | Conditions             | Min  | Typ  | Max  | Unit          |
|-------------------------------------------------------------------|--------------------------------------------------|------------------------|------|------|------|---------------|
| $I_{DDA5}$                                                        | analog supply current 5 for on-chip power supply | Europe/US band         | -    | 6.4  | -    | mA            |
|                                                                   |                                                  | Japan/East Europe band | 7.5  | 10   | 12   | mA            |
| $I_{DDA6}$                                                        | analog supply current 6 for on-chip power supply |                        | -    | 20.5 | -    | mA            |
| $I_{DDD}$                                                         | digital supply current                           | Europe/US band         | 20   | 25   | 31   | mA            |
|                                                                   |                                                  | Japan/East Europe band | 25   | 32   | 39.5 | mA            |
| $I_{MIX1OUT1}$                                                    | bias current of FM mixer output 1                |                        | 4.8  | 6    | 7.2  | mA            |
| $I_{MIX1OUT2}$                                                    | bias current of FM mixer output 2                |                        | 4.8  | 6    | 7.2  | mA            |
| <b>Supply current in AM mode</b>                                  |                                                  |                        |      |      |      |               |
| $I_{DDA1}$                                                        | analog supply current 1 for AM mixer 2           |                        | -    | 140  | -    | $\mu\text{A}$ |
| $I_{DDA2}$                                                        | analog supply current 2 for RF                   |                        | -    | 2.6  | -    | mA            |
| $I_{DDA3}$                                                        | analog supply current 3 for tuning PLL           |                        | -    | 2.2  | -    | mA            |
| $I_{DDA4}$                                                        | analog supply current 4 for VCO                  |                        | 5    | 6.5  | 8    | mA            |
| $I_{DDA5}$                                                        | analog supply current 5 for on-chip power supply |                        | 14   | 18.5 | 23   | mA            |
| $I_{DDA6}$                                                        | analog supply current 6 for on-chip power supply |                        | -    | 16.7 | -    | mA            |
| $I_{DDD}$                                                         | digital supply current                           |                        | 21   | 26   | 32   | mA            |
| $I_{MIX1OUT1}$                                                    | bias current of AM mixer 1 output 1              |                        | 4.8  | 6    | 7.2  | mA            |
| $I_{MIX1OUT2}$                                                    | bias current of AM mixer 1 output 2              |                        | 4.8  | 6    | 7.2  | mA            |
| $I_{AMMIX2OUT1}$                                                  | bias current of AM mixer 2 output 1              |                        | 3.6  | 4.5  | 5.4  | mA            |
| $I_{AMMIX2OUT2}$                                                  | bias current of AM mixer 2 output 2              |                        | 3.6  | 4.5  | 5.4  | mA            |
| <b>On-chip power supply reference current generator: pin IREF</b> |                                                  |                        |      |      |      |               |
| $V_{o(\text{ref})}$                                               | output reference voltage                         |                        | 4    | 4.25 | 4.5  | V             |
| $R_o$                                                             | output resistance                                |                        | -    | 10   | -    | k $\Omega$    |
| $I_{o(\text{source})(\text{max})}$                                | maximum output source current                    |                        | -100 | -    | +100 | nA            |

## 13. Dynamic characteristics

**Table 33: Dynamic characteristics**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                                                   | Parameter                                         | Conditions                                                                                                            | Min   | Typ  | Max   | Unit                                  |
|--------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-------|------|-------|---------------------------------------|
| <b>Voltage controlled oscillator</b>                                     |                                                   |                                                                                                                       |       |      |       |                                       |
| $f_{osc}$                                                                | oscillator frequency                              |                                                                                                                       | 159.9 | -    | 248.2 | MHz                                   |
| C/N                                                                      | carrier-to-noise ratio                            | $f_{osc} = 200 \text{ MHz}$ ; $\Delta f = 10 \text{ kHz}$ ;<br>$B = 1 \text{ Hz}$                                     | -     | 97   | -     | dBc                                   |
| RR                                                                       | ripple rejection $\frac{\Delta f_{osc}}{f_{osc}}$ | $f_{ripple} = 100 \text{ Hz}$ ;<br>$V_{DDA4(ripple)} = 100 \text{ mV}$ ;<br>$f_{osc} = 200 \text{ MHz}$               | 92    | 99   | -     | dB                                    |
| <b>Crystal oscillator</b>                                                |                                                   |                                                                                                                       |       |      |       |                                       |
| $f_{xtal}$                                                               | crystal frequency                                 |                                                                                                                       | -     | 20.5 | -     | MHz                                   |
| C/N                                                                      | carrier-to-noise ratio                            | $f_{xtal} = 20.5 \text{ MHz}$ ; $\Delta f = 10 \text{ kHz}$                                                           | -     | 112  | -     | $\frac{\text{dBc}}{\sqrt{\text{Hz}}}$ |
| <b>Circuit inputs: pins XTAL1, XTAL2 and XTALGND <a href="#">[1]</a></b> |                                                   |                                                                                                                       |       |      |       |                                       |
| $V_{xtal}$                                                               | crystal voltage                                   |                                                                                                                       | 80    | 100  | 160   | mV                                    |
| $V_{XTAL1}$ ,<br>$V_{XTAL2}$                                             | DC bias voltage                                   |                                                                                                                       | 1.7   | 2.1  | 2.5   | V                                     |
| $R_i$                                                                    | real part of input impedance                      | $V_{XTAL1} - V_{XTAL2} = 1 \text{ mV}$                                                                                | -250  | -    | -     | $\Omega$                              |
| $C_i$                                                                    | input capacitance                                 |                                                                                                                       | 8     | 10   | 12    | pF                                    |
| <b>Synthesizer</b>                                                       |                                                   |                                                                                                                       |       |      |       |                                       |
| <b>Programmable divider</b>                                              |                                                   |                                                                                                                       |       |      |       |                                       |
| $N_{prog}$                                                               | programmable divider ratio                        |                                                                                                                       | 512   | -    | 32767 |                                       |
| $\Delta N_{step}$                                                        | programmable divider step size                    |                                                                                                                       | -     | 1    | -     |                                       |
| <b>Charge pump: pin CPOUT</b>                                            |                                                   |                                                                                                                       |       |      |       |                                       |
| $I_{sink(cp1)}$                                                          | low charge pump 1 peak sink current               | FM weather band mode;<br>$0.4 \text{ V} < V_{CPOUT} < 7.6 \text{ V}$ ;<br>$f_{VCO} > f_{ref} \times N_{prog}$         | -     | 300  | -     | $\mu\text{A}$                         |
| $I_{source(cp1)}$                                                        | low charge pump 1 peak source current             | FM weather band mode;<br>$0.4 \text{ V} < V_{CPOUT} < 7.6 \text{ V}$ ;<br>$f_{VCO} < f_{ref} \times N_{prog}$         | -     | -300 | -     | $\mu\text{A}$                         |
| $I_{sink(cp1)h}$                                                         | high charge pump 1 peak sink current              | $0.4 \text{ V} < V_{CPOUT} < 7.6 \text{ V}$ ;<br>$f_{VCO} > f_{ref} \times N_{prog}$                                  |       |      |       |                                       |
|                                                                          |                                                   | AM mode                                                                                                               | -     | 1    | -     | mA                                    |
|                                                                          |                                                   | FM East Europe band                                                                                                   | -     | 1    | -     | mA                                    |
| $I_{source(cp1)h}$                                                       | high charge pump 1 peak source current            | $0.4 \text{ V} < V_{CPOUT} < 7.6 \text{ V}$ ;<br>$f_{VCO} < f_{ref} \times N_{prog}$                                  |       |      |       |                                       |
|                                                                          |                                                   | AM mode                                                                                                               | -     | -1   | -     | mA                                    |
|                                                                          |                                                   | FM East Europe band                                                                                                   | -     | -1   | -     | mA                                    |
| $I_{sink(cp2)}$                                                          | charge pump 2 peak sink current                   | FM standard or FM Japan mode;<br>$f_{VCO} > f_{ref} \times N_{prog}$ ;<br>$0.3 \text{ V} < V_{CPOUT} < 7.1 \text{ V}$ | -     | 130  | -     | $\mu\text{A}$                         |

**Table 33: Dynamic characteristics ...continued**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol            | Parameter                         | Conditions                                                                                                         | Min | Typ  | Max | Unit          |
|-------------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------|-----|------|-----|---------------|
| $I_{source(cp2)}$ | charge pump 2 peak source current | FM standard or FM Japan mode; $f_{VCO} < f_{ref} \times N_{prog}$ ;<br>$0.3 \text{ V} < V_{CPOUT} < 7.1 \text{ V}$ | -   | -130 | -   | $\mu\text{A}$ |

**Charge pump: pin VTUNE**

|                   |                                   |                                                                                                                    |   |    |   |    |
|-------------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------|---|----|---|----|
| $I_{sink(cp3)}$   | charge pump 3 peak sink current   | FM standard or FM Japan mode; $f_{VCO} > f_{ref} \times N_{prog}$ ;<br>$0.4 \text{ V} < V_{VTUNE} < 7.6 \text{ V}$ | - | 3  | - | mA |
| $I_{source(cp3)}$ | charge pump 3 peak source current | FM standard or FM Japan mode; $f_{VCO} < f_{ref} \times N_{prog}$ ;<br>$0.4 \text{ V} < V_{VTUNE} < 7.6 \text{ V}$ | - | -3 | - | mA |

**Antenna Digital Auto Alignment (DAA)****DAA input: pin DAAIN**

|                |                                       |                                             |     |   |     |    |
|----------------|---------------------------------------|---------------------------------------------|-----|---|-----|----|
| $I_{bias(cp)}$ | charge pump buffer input bias current | $V_{DAAIN} = 0.4 \text{ V to } 8 \text{ V}$ | -10 | - | +10 | nA |
| $V_{i(cp)}$    | charge pump buffer input voltage      |                                             | 0   | - | 8.5 | V  |

**DAA output: pin DAAOUT**

|                      |                                               |                                                                                                                                        |                                  |           |              |               |
|----------------------|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------|--------------|---------------|
| $V_{o(AM)}$          | DAA output voltage in AM mode                 | $I_{DAAOUT} < 100 \mu\text{A}$                                                                                                         | -                                | -         | 0.3          | V             |
| $V_{o(FM)}$          | DAA output voltage in FM mode                 | $V_{DAATD} = 0.45 \text{ V}$                                                                                                           |                                  |           |              |               |
|                      |                                               | minimum value;<br>data byte 2 = 1000 0000<br>(n = 0); $V_{DAAIN} = 0.5 \text{ V}$                                                      | -                                | -         | 0.5          | V             |
|                      |                                               | data byte 2 = 1010 1010<br>(n = 42); $V_{DAAIN} = 2 \text{ V}$                                                                         | 1.2                              | 1.4       | 1.6          | V             |
|                      |                                               | data byte 2 = 1101 0101<br>(n = 85); $V_{DAAIN} = 2 \text{ V}$                                                                         | <a href="#">[2]</a> 2.3          | 2.6       | 2.9          | V             |
|                      |                                               | data byte 2 = 1000 0000<br>(n = 0); $V_{DAAIN} = 4 \text{ V}$                                                                          | <a href="#">[2]</a> 0.4          | 0.65      | 1            | V             |
|                      |                                               | data byte 2 = 1100 0000<br>(n = 64); $V_{DAAIN} = 4 \text{ V}$                                                                         | 3.8                              | 4         | 4.2          | V             |
|                      |                                               | maximum value;<br>data byte 2 = 1111 1111<br>(n = 127); $V_{DAAIN} = 4.7 \text{ V}$                                                    | 8                                | -         | 8.5          | V             |
| $V_{o(n)}$           | DAA output noise voltage                      | data byte 2 = 1100 0000<br>(n = 64); FM mode;<br>$V_{DAAIN} = 4 \text{ V}$ ;<br>$V_{DAATD} = 0.45 \text{ V}$ ;<br>B = 300 Hz to 22 kHz | -                                | 30        | 100          | $\mu\text{V}$ |
| $\Delta V_{o(T)}$    | DAA output voltage variation with temperature | $T_{amb} = -40^\circ\text{C to } +85^\circ\text{C}$ ;<br>data byte 2 = 1100 0000<br>(n = 64)                                           | -8                               | -         | +8           | mV            |
| $\Delta V_{o(step)}$ | DAA step accuracy                             | FM mode; n = 0 to 127;<br>$V_{DAAOUT} = 0.5 \text{ V to } 8 \text{ V}$ ;<br>$V_{DAAIN} = 2 \text{ V}$ ; $V_{DAATD} = 0.45 \text{ V}$   | <a href="#">[3]</a> $0.5V_{LSB}$ | $V_{LSB}$ | $1.5V_{LSB}$ | mV            |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see Figure 8; all AC values are given in RMS; unless otherwise specified.

| Symbol                                  | Parameter                                                    | Conditions                                                                                                                                                                           | Min            | Typ | Max        | Unit                       |
|-----------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----|------------|----------------------------|
| $\Delta V_{o(sink)}$                    | DAA output voltage variation caused by sink current          | $V_{DAAIN} = 4\text{ V}$ ;<br>$I_{DAAOUT} = 50\text{ }\mu\text{A}$                                                                                                                   | [3] $-V_{LSB}$ | -   | $+V_{LSB}$ | mV                         |
| $\Delta V_{o(source)}$                  | DAA output voltage variation caused by source current        | $V_{DAAIN} = 4\text{ V}$ ;<br>$I_{DAAOUT} = -50\text{ }\mu\text{A}$                                                                                                                  | [3] $-V_{LSB}$ | -   | $+V_{LSB}$ | mV                         |
| $t_{st}$                                | DAA output settling time                                     | $V_{DAAOUT} = 0.2\text{ V to } 8.25\text{ V}$ ;<br>$C_L = 270\text{ pF}$                                                                                                             | -              | 20  | 30         | $\mu\text{s}$              |
| RR                                      | ripple rejection $\frac{V_{DAAOUT}}{V_{DDA3}}$               | data byte 2 = 1010 1011<br>(n = 43); FM mode;<br>$V_{DAAIN} = 4\text{ V}$ ;<br>$V_{DAATD} = 0.45\text{ V}$ ;<br>$f_{ripple} = 100\text{ Hz}$ ;<br>$V_{DDA3(ripple)} = 100\text{ mV}$ | -              | 65  | -          | dB                         |
| $C_L$                                   | DAA output load capacitance                                  |                                                                                                                                                                                      | -              | -   | 270        | pF                         |
| DAA temperature compensation: pin DAATD |                                                              |                                                                                                                                                                                      |                |     |            |                            |
| $I_{source}$                            | compensation diode source current                            | $V_{DAATD} = 0.2\text{ V to } 1.2\text{ V}$                                                                                                                                          | -50            | -40 | -30        | $\mu\text{A}$              |
| $TC_{source}$                           | temperature coefficient of compensation diode source current | $V_{DAATD} = 0.2\text{ V to } 1.2\text{ V}$ ;<br>$T_{amb} = -40\text{ }^{\circ}\text{C to } +85\text{ }^{\circ}\text{C}$                                                             | -300           | -   | +300       | $\frac{10^{-6}}{\text{K}}$ |
| IF counter (FM IF or AM IF2 counter)    |                                                              |                                                                                                                                                                                      |                |     |            |                            |
| $N_{IF}$                                | IF counter length for AM and FM                              |                                                                                                                                                                                      | -              | 8   | -          | bit                        |
| AM mode                                 |                                                              |                                                                                                                                                                                      |                |     |            |                            |
| $V_{sen}$                               | sensitivity voltage (pin AMIF2IN to AMIF2DEC)                | m = 0                                                                                                                                                                                | -              | 30  | 70         | $\mu\text{V}$              |
| N                                       | counter result (decimal)                                     | $V_{AMIF2IN-AMIF2DEC} = 200\text{ }\mu\text{V}$                                                                                                                                      |                |     |            |                            |
|                                         |                                                              | period = 2 ms                                                                                                                                                                        | -              | 132 | -          |                            |
|                                         |                                                              | period = 20 ms                                                                                                                                                                       | -              | 40  | -          |                            |
| FM mode                                 |                                                              |                                                                                                                                                                                      |                |     |            |                            |
| $V_{sen}$                               | sensitivity voltage (pin FMIFIN to FMIFDEC)                  |                                                                                                                                                                                      | -              | 60  | 100        | $\mu\text{V}$              |
| N                                       | counter result (decimal)                                     | period = 2 ms;<br>$V_{FMIFIN-FMIFDEC} = 100\text{ }\mu\text{V}$                                                                                                                      |                |     |            |                            |
|                                         |                                                              | prescaler ratio = 10                                                                                                                                                                 | -              | 92  | -          |                            |
|                                         |                                                              | prescaler ratio = 100                                                                                                                                                                | -              | 214 | -          |                            |
|                                         |                                                              | period = 20 ms;<br>$V_{FMIFIN-FMIFDEC} = 100\text{ }\mu\text{V}$                                                                                                                     |                |     |            |                            |
|                                         |                                                              | prescaler ratio = 10                                                                                                                                                                 | -              | 152 | -          |                            |
|                                         |                                                              | prescaler ratio = 100                                                                                                                                                                | -              | 92  | -          |                            |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                                | Parameter                                                  | Conditions                                                    | Min  | Typ  | Max                   | Unit |
|-------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------------|------|------|-----------------------|------|
| I <sup>2</sup> C-bus address select: pin ADDRSEL      |                                                            |                                                               |      |      |                       |      |
| R <sub>L</sub>                                        | load resistance to ground                                  | 1st I <sup>2</sup> C-bus address                              | 1    | -    | -                     | MΩ   |
|                                                       |                                                            | 2nd I <sup>2</sup> C-bus address                              | 108  | 120  | 132                   | kΩ   |
|                                                       |                                                            | 3rd I <sup>2</sup> C-bus address                              | 29.7 | 33   | 36.3                  | kΩ   |
| I <sup>2</sup> C-bus enable: pin BUSENABLE            |                                                            |                                                               |      |      |                       |      |
| V <sub>IL</sub>                                       | LOW-level input voltage                                    |                                                               | −0.3 | -    | +1                    | V    |
| V <sub>IH</sub>                                       | HIGH-level input voltage                                   |                                                               | 2    | -    | V <sub>DD</sub> + 0.3 | V    |
| Software programmable ports: pins SWPORT1 and SWPORT2 |                                                            |                                                               |      |      |                       |      |
| I <sub>sink(max)</sub>                                | maximum sink current                                       | bit SWPORT1 = 1                                               | 1    | -    | 1.6                   | mA   |
|                                                       |                                                            | bit SWPORT2 = 1                                               | 1    | -    | 1.6                   | mA   |
| Weather band flag: pin WBFLAG                         |                                                            |                                                               |      |      |                       |      |
| I <sub>source(max)</sub>                              | maximum source current                                     | R = 560 Ω                                                     | −6   | −5   | −4                    | mA   |
| R <sub>i(shunt)</sub>                                 | internal shunt resistance to ground                        |                                                               | -    | 50   | -                     | kΩ   |
| V <sub>o(FM)(max)</sub>                               | maximum output voltage for FM mode                         | measured with respect to pin RFGND                            | 0    | -    | 0.2                   | V    |
| V <sub>o(WB)</sub>                                    | output voltage for weather band mode                       | measured with respect to pin RFGND                            | 4    | -    | 5                     | V    |
| AM signal channel                                     |                                                            |                                                               |      |      |                       |      |
| AM RF AGC: pins AMMIX1IN and AMMIX1DEC                |                                                            |                                                               |      |      |                       |      |
| V <sub>i(RF)(p)</sub>                                 | RF input voltage for wideband AGC start level (peak value) | m = 0.3; f <sub>AF</sub> = 1 kHz                              |      |      |                       |      |
|                                                       |                                                            | AGC[1:0] = 00                                                 | 375  | 530  | 750                   | mV   |
|                                                       |                                                            | AGC[1:0] = 01                                                 | 300  | 420  | 590                   | mV   |
|                                                       |                                                            | AGC[1:0] = 10                                                 | 210  | 290  | 410                   | mV   |
|                                                       |                                                            | AGC[1:0] = 11                                                 | 110  | 150  | 210                   | mV   |
| AM IF AGC stage inputs: pins AMIF2IN and AMIF2DEC     |                                                            |                                                               |      |      |                       |      |
| V <sub>i(IF2)</sub>                                   | IF2 input voltage                                          | AGC start level                                               |      |      |                       |      |
|                                                       |                                                            | m = 0                                                         | 0.09 | 0.12 | 0.19                  | V    |
|                                                       |                                                            | m = 0.8                                                       | 0.07 | 0.10 | 0.14                  | V    |
| AM RF AGC PIN diode drive: pin IAMAGC                 |                                                            |                                                               |      |      |                       |      |
| I <sub>sink(max)</sub>                                | maximum AGC sink current                                   | V <sub>IAMAGC</sub> = 2.8 V                                   | 9    | 14   | 18                    | mA   |
| I <sub>sink</sub>                                     | AGC sink current                                           | FM mode; V <sub>IAMAGC</sub> = 2.8 V                          | 1    | 1.5  | 2                     | mA   |
| R <sub>o</sub>                                        | output resistance                                          | I <sub>IAMAGC</sub> = 1 μA                                    | 0.5  | -    | -                     | MΩ   |
| C <sub>o</sub>                                        | output capacitance                                         |                                                               | -    | 5    | 7                     | pF   |
| AM RF AGC cascode stage: pin VAMCAS                   |                                                            |                                                               |      |      |                       |      |
| V <sub>cas</sub>                                      | cascode voltage                                            | V <sub>AMMIX1IN-AMMIX1DEC</sub> below threshold; maximum gain | 4.5  | 5    | 5.5                   | V    |
| I <sub>cas</sub>                                      | cascode transistor base current capability                 |                                                               | 100  | -    | -                     | μA   |
| I <sub>cas(off)</sub>                                 | cascode transistor base off current                        | FM mode                                                       | -    | -    | 100                   | nA   |

**Table 33: Dynamic characteristics ...continued**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                                                   | Parameter                                                                                                          | Conditions                                                                                                                                  | Min  | Typ                 | Max  | Unit                         |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------|------|------------------------------|
| <b>AM RF AGC cascode stage: pin VAMCASFB</b>                             |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| $V_{cas(FB)}$                                                            | cascode voltage                                                                                                    | $V_{AMMIX1IN}$ - $AMMIX1DEC$ above threshold; minimum gain                                                                                  | 0.2  | 0.28                | 0.35 | V                            |
| $I_{cas(FB)}$                                                            | cascode feedback sense current                                                                                     |                                                                                                                                             | 0    | 0.4                 | 1    | $\mu\text{A}$                |
| <b>AM RF AGC transconductance buffer: pin AGCBUF <a href="#">[4]</a></b> |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| $g_{m(buf)}$                                                             | buffer transconductance<br>$\frac{\Delta I_{AGCBUF}}{\Delta V_{TRFAMAGC}}$                                         | AM mode;<br>$\Delta V_{TRFAMAGC} = 50 \text{ mV to } 0.4 \text{ V}$                                                                         | 0.85 | 1.1                 | 1.35 | mS                           |
| $I_{sink(max)}$                                                          | maximum sink current                                                                                               | AM mode; open-collector;<br>$\Delta V_{TRFAMAGC} = 0.8 \text{ V}$                                                                           | 450  | 500                 | 560  | $\mu\text{A}$                |
| $I_{source(max)}$                                                        | maximum source current                                                                                             | AM mode;<br>$\Delta V_{TRFAMAGC} < 50 \text{ mV}$                                                                                           | -    | -                   | -30  | $\mu\text{A}$                |
| $V_{o(n)}$                                                               | buffer output noise voltage                                                                                        | AM mode;<br>$V_{DDA2} - V_{AGCBUF} = 1 \text{ V}$<br>(voltage across external pull-up resistor);<br>$B = 400 \text{ Hz to } 20 \text{ kHz}$ | -    | 10                  | 15   | $\mu\text{V}$                |
| <b>AM mixer 1 (IF1 = 10.7 MHz)</b>                                       |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| <b>Mixer inputs: pins AMMIX1IN and AMMIX1DEC</b>                         |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| $R_i$                                                                    | input resistance                                                                                                   |                                                                                                                                             | 15   | 25                  | 40   | $\text{k}\Omega$             |
| $C_i$                                                                    | input capacitance                                                                                                  |                                                                                                                                             | 2.5  | 5                   | 7.5  | pF                           |
| $V_i$                                                                    | DC input voltage                                                                                                   |                                                                                                                                             | 2.3  | 2.7                 | 3.1  | V                            |
| $V_{i(max)}$                                                             | maximum input voltage                                                                                              | 1 dB compression point of AM mixer 1 output; $m = 0$                                                                                        | 500  | -                   | -    | mV                           |
| <b>Mixer outputs: pins MIX1OUT1 and MIX1OUT2</b>                         |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| $R_o$                                                                    | output resistance                                                                                                  |                                                                                                                                             | 100  | -                   | -    | $\text{k}\Omega$             |
| $C_o$                                                                    | output capacitance                                                                                                 |                                                                                                                                             | -    | 4                   | 7    | pF                           |
| $V_{o(max)(p-p)}$                                                        | maximum output voltage (peak-to-peak value)                                                                        |                                                                                                                                             | 12   | 15                  | -    | V                            |
| $I_{bias}$                                                               | mixer bias current                                                                                                 | AM mode                                                                                                                                     | 4.8  | 6                   | 7.2  | mA                           |
| <b>Mixer</b>                                                             |                                                                                                                    |                                                                                                                                             |      |                     |      |                              |
| $g_{m(conv)}$                                                            | conversion transconductance<br>$\frac{I_{IF1}}{V_{RF}}$                                                            |                                                                                                                                             | 3.9  | 5.2                 | 6.5  | $\frac{\text{mA}}{\text{V}}$ |
| $g_{m(conv)(T)}$                                                         | conversion transconductance variation with temperature<br>$\frac{\Delta g_{m(conv)}}{g_{m(conv)} \times \Delta T}$ |                                                                                                                                             | -    | $-9 \times 10^{-4}$ | -    | $\text{K}^{-1}$              |

**Table 33: Dynamic characteristics ...continued**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                               | Parameter                                                                                                          | Conditions                                                                                    | Min | Typ                 | Max  | Unit                                 |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----|---------------------|------|--------------------------------------|
| IP3                                                  | 3rd-order intermodulation                                                                                          | $R_L = 2.6 \text{ k}\Omega$ (AC load between output pins);<br>$\Delta f = 300 \text{ kHz}$    | 135 | 138                 | -    | $\text{dB}\mu\text{V}$               |
| IP2                                                  | 2nd-order intermodulation                                                                                          | $R_L = 2.6 \text{ k}\Omega$ (AC load between output pins)                                     | -   | 170                 | -    | $\text{dB}\mu\text{V}$               |
| $V_{i(n)(eq)}$                                       | equivalent input noise voltage                                                                                     | $R_{gen} = 750 \text{ }\Omega$ ; $R_L = 2.6 \text{ k}\Omega$<br>(AC load between output pins) | -   | 5.8                 | 8    | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| F                                                    | noise figure of AM mixer 1                                                                                         |                                                                                               | -   | 4.5                 | 7.1  | dB                                   |
| <b>AM mixer 2 (IF2 = 450 kHz)</b>                    |                                                                                                                    |                                                                                               |     |                     |      |                                      |
| <i>Mixer inputs: pins IFAMPIN and IFAMPDEC</i>       |                                                                                                                    |                                                                                               |     |                     |      |                                      |
| $R_i$                                                | input resistance                                                                                                   |                                                                                               | -   | 330                 | -    | $\Omega$                             |
| $C_i$                                                | input capacitance                                                                                                  |                                                                                               | -   | 5                   | 7    | pF                                   |
| $V_i$                                                | DC input voltage                                                                                                   |                                                                                               | 2.4 | 2.7                 | 3    | V                                    |
| $V_{i(max)(p)}$                                      | maximum input voltage (peak value)                                                                                 | 1 dB compression point of AM mixer 2 output                                                   | 1.1 | 1.4                 | -    | V                                    |
| <i>Mixer outputs: pins AMMIX2OUT1 and AMMIX2OUT2</i> |                                                                                                                    |                                                                                               |     |                     |      |                                      |
| $R_o$                                                | output resistance                                                                                                  |                                                                                               | 50  | -                   | -    | $\text{k}\Omega$                     |
| $C_o$                                                | output capacitance                                                                                                 |                                                                                               | -   | 4                   | 7    | pF                                   |
| $V_{o(max)(p-p)}$                                    | maximum output voltage (peak-to-peak value)                                                                        |                                                                                               | 12  | 15                  | -    | V                                    |
| $I_{bias}$                                           | mixer bias current                                                                                                 | AM mode                                                                                       | 3.6 | 4.5                 | 5.4  | mA                                   |
| $I_L$                                                | mixer leakage current                                                                                              | FM mode                                                                                       | -   | -                   | 10   | $\mu\text{A}$                        |
| <i>Mixer</i>                                         |                                                                                                                    |                                                                                               |     |                     |      |                                      |
| $g_{m(conv)}$                                        | conversion transconductance $\frac{I_{IF2}}{V_{IF1}}$                                                              |                                                                                               | 3.2 | 4.3                 | 5.4  | $\frac{\text{mA}}{\text{V}}$         |
| $g_{m(conv)(T)}$                                     | conversion transconductance variation with temperature<br>$\frac{\Delta g_{m(conv)}}{g_{m(conv)} \times \Delta T}$ |                                                                                               | -   | $-9 \times 10^{-4}$ | -    | $\text{K}^{-1}$                      |
| IP3                                                  | 3rd-order intermodulation                                                                                          | $R_L = 1.5 \text{ k}\Omega$ (AC load between output pins);<br>$\Delta f = 300 \text{ kHz}$    | 134 | 137                 | -    | $\text{dB}\mu\text{V}$               |
| IP2                                                  | 2nd-order intermodulation                                                                                          | $R_L = 1.5 \text{ k}\Omega$ (AC load between output pins)                                     | -   | 170                 | -    | $\text{dB}\mu\text{V}$               |
| $V_{i(n)(eq)}$                                       | equivalent input noise voltage                                                                                     | $R_{gen} = 330 \text{ }\Omega$ ; $R_L = 1.5 \text{ k}\Omega$<br>(AC load between output pins) | -   | 15                  | 22   | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| F                                                    | noise figure of AM mixer 2                                                                                         |                                                                                               | -   | 16                  | 19.5 | dB                                   |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                                                     | Parameter                                                                                      | Conditions                                                                                                             | Min | Typ  | Max  | Unit                                 |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-----|------|------|--------------------------------------|
| AM IF2 AGC stage: pins AMIF2IN and AMIF2DEC                                |                                                                                                |                                                                                                                        |     |      |      |                                      |
| G <sub>AGC(max)</sub>                                                      | maximum AGC amplifier gain                                                                     | no AGC active                                                                                                          | 38  | 41   | 44   | dB                                   |
| V <sub>AGC(start)</sub>                                                    | AGC start voltage (pin IFOUT)                                                                  | −3 dB below maximum output level; R <sub>L</sub> = 1 kΩ                                                                | 93  | -    | 98   | dBμV                                 |
| ΔAGC                                                                       | AGC range                                                                                      | between start and stop of AGC                                                                                          | 52  | -    | -    | dB                                   |
| THD                                                                        | total harmonic distortion of IF2 output signal                                                 | AM signal; f <sub>mod</sub> = 400 Hz; m = 0.8; C <sub>TAMIF2AGC</sub> = 4.7 μF; V <sub>AMIF2IN-AMIF2DEC</sub> < 0.14 V | -   | -    | 0.3  | %                                    |
| V <sub>i(n)(eq)</sub>                                                      | equivalent input noise voltage                                                                 | R <sub>gen</sub> = 1.5 kΩ                                                                                              | -   | 10.5 | -    | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| R <sub>i</sub>                                                             | input resistance                                                                               |                                                                                                                        | 1.3 | 1.5  | 1.65 | kΩ                                   |
| C <sub>i</sub>                                                             | input capacitance                                                                              |                                                                                                                        | -   | -    | 5    | pF                                   |
| AM IF2 AGC stage: pin IFOUT                                                |                                                                                                |                                                                                                                        |     |      |      |                                      |
| V <sub>o(rms)</sub>                                                        | AM IF2 output voltage (RMS value)                                                              | R <sub>L</sub> = 1 kΩ; AGC active                                                                                      | 63  | 84   | 112  | mV                                   |
| t <sub>st</sub>                                                            | AM IF2 AGC settling time                                                                       | V <sub>AMIF2IN</sub> = 10 mV to 100 mV                                                                                 | -   | 60   | -    | ms                                   |
|                                                                            |                                                                                                | V <sub>AMIF2IN</sub> = 100 mV to 10 mV                                                                                 | -   | 360  | -    | ms                                   |
|                                                                            |                                                                                                | V <sub>AMIF2IN</sub> = 140 μV to 140 mV                                                                                | -   | 150  | -    | ms                                   |
|                                                                            |                                                                                                | V <sub>AMIF2IN</sub> = 140 mV to 140 μV                                                                                | -   | 600  | -    | ms                                   |
| AM IF2 level detector output: pin VLEVEL; see <a href="#">Figure 4</a> [5] |                                                                                                |                                                                                                                        |     |      |      |                                      |
| V <sub>VLEVEL</sub>                                                        | DC output voltage                                                                              | V <sub>i</sub> = 10 μV to 1 V                                                                                          | 0   | -    | 5    | V                                    |
|                                                                            |                                                                                                | V <sub>i</sub> < 1 μV; standard setting of level DAA                                                                   | 0.1 | 0.35 | 0.8  | V                                    |
|                                                                            |                                                                                                | V <sub>i</sub> = 1.4 mV; standard setting of level DAA                                                                 | 1.6 | 2.2  | 2.8  | V                                    |
| ΔV <sub>level</sub>                                                        | step size for adjustment of level starting point                                               | V <sub>i</sub> = 0 V; standard setting of level slope                                                                  | 40  | 53   | 70   | mV                                   |
| V <sub>level(slope)</sub>                                                  | slope of level voltage<br>$\frac{\Delta V_{\text{level}}}{\Delta V_{\text{AMIF2IN-AMIF2DEC}}}$ | V <sub>i</sub> = 140 μV to 140 mV; standard setting of level slope                                                     | 0.8 | 1    | 1.2  | $\frac{\text{V}}{20 \text{ dB}}$     |
| ΔV <sub>step</sub>                                                         | step size for adjustment of level slope                                                        | V <sub>i</sub> = 1.4 mV                                                                                                | 55  | 75   | 95   | $\frac{\text{mV}}{20 \text{ dB}}$    |
| B <sub>level</sub>                                                         | bandwidth of level output voltage                                                              | V <sub>i</sub> = 15 mV; standard setting of level DAA                                                                  | 200 | 300  | -    | kHz                                  |
| R <sub>o</sub>                                                             | output resistance                                                                              |                                                                                                                        | -   | -    | 500  | Ω                                    |
| RR                                                                         | ripple rejection $\frac{V_{\text{VLEVEL}}}{V_{\text{DDA6}}}$                                   | V <sub>DDA6(ripple)</sub> = 100 mV; f <sub>ripple</sub> = 100 Hz                                                       | -   | 40   | -    | dB                                   |

**Table 33: Dynamic characteristics ...continued**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                                                                                 | Parameter                                   | Conditions                                                                                                    | Min  | Typ   | Max  | Unit |
|----------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------|------|-------|------|------|
| AM noise blanker; AMNB = 1; test signal and test circuit; see <a href="#">Figure 3</a> |                                             |                                                                                                               |      |       |      |      |
| t <sub>sup</sub>                                                                       | suppression time                            | V <sub>pulse</sub> = 250 mV;<br>V <sub>VLEVEL</sub> < 1.8 V                                                   | 6    | 7.5   | 10   | μs   |
| f <sub>trigger</sub>                                                                   | trigger sensitivity frequency               | V <sub>pulse</sub> = 200 mV;<br>V <sub>VLEVEL</sub> < 1.8 V                                                   | -    | 1000  | -    | Hz   |
|                                                                                        |                                             | V <sub>pulse</sub> = 200 mV;<br>V <sub>VLEVEL</sub> > 2.2 V                                                   | -    | -     | 100  | Hz   |
|                                                                                        |                                             | V <sub>pulse</sub> = 20 mV;<br>V <sub>VLEVEL</sub> < 1.8 V                                                    | -    | -     | 100  | Hz   |
| I <sub>sink(AGC)</sub>                                                                 | AM noise blanker AGC sink current           | V <sub>TAMNBAGC</sub> = 3 V                                                                                   | 35   | 50    | 65   | μA   |
| V <sub>AGC</sub>                                                                       | AM noise blanker AGC voltage (pin TAMNBAGC) | AM mixer 1 input V <sub>i</sub> = 0 V                                                                         | 2    | 2.4   | 2.8  | V    |
| FM signal channel                                                                      |                                             |                                                                                                               |      |       |      |      |
| FM RF AGC (FM distance mode; LODX = 0)                                                 |                                             |                                                                                                               |      |       |      |      |
| RF input: pins FMMIXIN1 and FMMIXIN2; KAGC = 0                                         |                                             |                                                                                                               |      |       |      |      |
| V <sub>i(RF)</sub>                                                                     | RF input voltage for start of wideband AGC  | AGC[1:0] = 11                                                                                                 | -    | 3     | -    | mV   |
|                                                                                        |                                             | AGC[1:0] = 10                                                                                                 | -    | 6     | -    | mV   |
|                                                                                        |                                             | AGC[1:0] = 01                                                                                                 | -    | 9     | -    | mV   |
|                                                                                        |                                             | AGC[1:0] = 00                                                                                                 | -    | 12    | -    | mV   |
| FM RF AGC time constant: pin TFMAGC                                                    |                                             |                                                                                                               |      |       |      |      |
| R <sub>source</sub>                                                                    | source resistance                           |                                                                                                               | 4    | 5     | 6    | kΩ   |
| V <sub>O(ref)</sub>                                                                    | DC output reference voltage                 | AGC[1:0] = 00; KAGC = 0;<br>V <sub>FMMIXIN1-FMMIXIN2</sub> = 0 V                                              | 3.6  | 4.1   | 4.6  | V    |
| FM RF AGC PIN diode drive output: pin IFMAGC                                           |                                             |                                                                                                               |      |       |      |      |
| I <sub>sink(max)</sub>                                                                 | maximum AGC sink current                    | V <sub>IFMAGC</sub> = 2.5 V;<br>V <sub>TFMAGC</sub> = V <sub>O(ref)</sub> – 0.5 V;<br>AGC[1:0] = 00; KAGC = 0 | 8    | 11.5  | 15   | mA   |
| I <sub>source(max)</sub>                                                               | maximum AGC source current                  | V <sub>IFMAGC</sub> = 2.5 V;<br>V <sub>TFMAGC</sub> = V <sub>O(ref)</sub> + 0.5 V;<br>AGC[1:0] = 00; KAGC = 0 | –15  | –11.5 | –8   | mA   |
| I <sub>source(AGC)</sub>                                                               | AGC source current                          | AM mode                                                                                                       | –15  | –11.5 | –8   | mA   |
|                                                                                        |                                             | V <sub>IFMAGC</sub> = 2.5 V; LODX = 1                                                                         | –4.4 | –3.7  | –2.7 | mA   |
| FM keyed AGC: pin VLEVEL                                                               |                                             |                                                                                                               |      |       |      |      |
| V <sub>th</sub>                                                                        | threshold voltage for narrow-band AGC       | KAGC = 1;<br>V <sub>TFMAGC</sub> = V <sub>O(ref)</sub> + 0.6 V                                                | 0.6  | 0.75  | 0.9  | V    |
| FM RF AGC transconductance buffer: pin AGCBUF                                          |                                             |                                                                                                               |      |       |      |      |
| g <sub>m(buf)</sub>                                                                    | buffer transconductance                     | FM mode; V <sub>TFMAGC</sub> = V <sub>O(ref)</sub> to V <sub>O(ref)</sub> + 80 mV                             | 4    | 5.3   | 6.4  | mS   |
| I <sub>sink(max)</sub>                                                                 | maximum sink current                        | FM mode; open-collector;<br>V <sub>TFMAGC</sub> = V <sub>O(ref)</sub> + 0.15 V                                | 450  | 500   | 560  | μA   |
| I <sub>source(max)</sub>                                                               | maximum source current                      | FM mode; V <sub>TFMAGC</sub> = V <sub>O(ref)</sub>                                                            | -    | -     | –30  | μA   |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see Figure 8; all AC values are given in RMS; unless otherwise specified.

| Symbol                              | Parameter                                                | Conditions                                                                                                                          | Min | Typ                 | Max | Unit                         |
|-------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----|---------------------|-----|------------------------------|
| $V_{o(n)}$                          | buffer output noise voltage                              | FM mode;<br>$V_{VDDA2-AGCBUF} = 1 \text{ V}$ (voltage across external pull-up resistor);<br>$B = 400 \text{ Hz to } 20 \text{ kHz}$ | -   | 10                  | 15  | $\mu\text{V}$                |
| FM RF mixer                         |                                                          |                                                                                                                                     |     |                     |     |                              |
| Reference voltage: pin VREFFMMIX    |                                                          |                                                                                                                                     |     |                     |     |                              |
| $V_{ref}$                           | reference voltage                                        | FM mode                                                                                                                             | 6.6 | 7.3                 | 8   | V                            |
|                                     |                                                          | AM mode                                                                                                                             | 2.7 | 3.1                 | 3.4 | V                            |
| Inputs: pins FMMIXIN1 and FMMIXIN2  |                                                          |                                                                                                                                     |     |                     |     |                              |
| $R_i$                               | input resistance                                         | MIXGAIN = 0                                                                                                                         | -   | 3.5                 | -   | k $\Omega$                   |
|                                     |                                                          | MIXGAIN = 1                                                                                                                         | -   | 1.8                 | -   | k $\Omega$                   |
| $C_i$                               | input capacitance                                        |                                                                                                                                     | -   | 5                   | 7   | pF                           |
| $V_{BIAS}$                          | DC bias voltage                                          | FM mode                                                                                                                             | 2.2 | 2.7                 | 3.2 | V                            |
| $V_{i(RF)(p)}$                      | RF input voltage (peak value)                            | 1 dB compression point of FM mixer output                                                                                           |     |                     |     |                              |
|                                     |                                                          | MIXGAIN = 0                                                                                                                         | 70  | 100                 | -   | mV                           |
|                                     |                                                          | MIXGAIN = 1                                                                                                                         | 35  | 50                  | -   | mV                           |
| Outputs: pins MIX1OUT1 and MIX1OUT2 |                                                          |                                                                                                                                     |     |                     |     |                              |
| $R_o$                               | output resistance                                        |                                                                                                                                     | 100 | -                   | -   | k $\Omega$                   |
| $C_o$                               | output capacitance                                       |                                                                                                                                     | 2   | 3.5                 | 5   | pF                           |
| $V_{o(max)(p-p)}$                   | maximum output voltage (peak-to-peak value)              |                                                                                                                                     | 3   | -                   | -   | V                            |
| $I_{bias}$                          | mixer bias current                                       | FM mode                                                                                                                             | 4.8 | 6                   | 7.2 | mA                           |
| FM mixer                            |                                                          |                                                                                                                                     |     |                     |     |                              |
| $g_{m(conv)}$                       | conversion transconductance                              | MIXGAIN = 0                                                                                                                         | 8.5 | 12.5                | 18  | $\frac{\text{mA}}{\text{V}}$ |
|                                     | $\frac{I_{IF}}{V_{RF}}$                                  | MIXGAIN = 1                                                                                                                         | 17  | 25                  | 36  | $\frac{\text{mA}}{\text{V}}$ |
| $g_{m(conv)(T)}$                    | conversion transconductance variation with temperature   | MIXGAIN = 0                                                                                                                         | -   | $-1 \times 10^{-3}$ | -   | K $^{-1}$                    |
|                                     | $\frac{\Delta g_{m(conv)}}{g_{m(conv)} \times \Delta T}$ |                                                                                                                                     |     |                     |     |                              |
| F                                   | noise figure                                             | MIXGAIN = 0                                                                                                                         | -   | 3.5                 | 4.6 | dB                           |
|                                     |                                                          | MIXGAIN = 1                                                                                                                         | -   | 2.4                 | -   | dB                           |
| IP3                                 | 3rd-order intermodulation                                | MIXGAIN = 0                                                                                                                         | 113 | 117                 | -   | dB $\mu\text{V}$             |
|                                     |                                                          | MIXGAIN = 1                                                                                                                         | -   | 108                 | -   | dB $\mu\text{V}$             |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5\text{ V}$ ;  $V_{DDA5} = 5\text{ V}$ ;  
 $V_{DDD} = 5\text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                            | Parameter                                                 | Conditions                                                                                            | Min | Typ  | Max | Unit                                 |
|-----------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----|------|-----|--------------------------------------|
| IRR                               | image rejection ratio                                     | FMINJ = 1 <a href="#">[6]</a>                                                                         |     |      |     |                                      |
|                                   |                                                           | $f_{RFwanted} = 87.5\text{ MHz};$<br>$f_{RFimage} = 108.9\text{ MHz}$                                 | 25  | 30   | -   | dB                                   |
|                                   |                                                           | data byte 3 = X010X110;<br>$f_{RFwanted} = 162.475\text{ MHz};$<br>$f_{RFimage} = 183.875\text{ MHz}$ | 22  | 30   | -   | dB                                   |
| $V_{i(n)(eq)}$                    | equivalent input noise voltage (pin FMMIXIN1 to FMMIXIN2) | $R_{gen} = 200\ \Omega; R_L = 2.6\text{ k}\Omega$                                                     |     |      |     |                                      |
|                                   |                                                           | MIXGAIN = 0                                                                                           | -   | 2.9  | 3.1 | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
|                                   |                                                           | MIXGAIN = 1                                                                                           | -   | 2.6  | -   | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $R_{gen(opt)}$                    | optimum generator resistance                              |                                                                                                       | -   | 200  | -   | $\Omega$                             |
| FM IF amplifier (IBOC = 0)        |                                                           |                                                                                                       |     |      |     |                                      |
| G                                 | gain                                                      | $R_L = 330\ \Omega; V_i = 1\text{ mV}$ <a href="#">[7]</a>                                            |     |      |     |                                      |
|                                   |                                                           | IFGAIN = 0                                                                                            | -   | 10.5 | -   | dB                                   |
|                                   |                                                           | IFGAIN = 1                                                                                            | -   | 14   | -   | dB                                   |
| F                                 | noise figure                                              | IFGAIN = 0                                                                                            | -   | 10   | -   | dB                                   |
|                                   |                                                           | IFGAIN = 1                                                                                            | -   | 8.3  | -   | dB                                   |
| IP3                               | 3rd-order intermodulation                                 | IFGAIN = 0                                                                                            | -   | 123  | -   | dB $\mu$ V                           |
|                                   |                                                           | IFGAIN = 1                                                                                            | -   | 119  | -   | dB $\mu$ V                           |
| Inputs: pins IFAMPIN and IFAMPDEC |                                                           |                                                                                                       |     |      |     |                                      |
| $V_{i(max)(p)}$                   | maximum input voltage (peak value)                        | 1 dB compression point of FM IF amplifier output voltage                                              |     |      |     |                                      |
|                                   |                                                           | IFGAIN = 0                                                                                            | 400 | -    | -   | mV                                   |
|                                   |                                                           | IFGAIN = 1                                                                                            | 250 | -    | -   | mV                                   |
| $V_{i(n)(eq)}$                    | equivalent input noise voltage                            | $R_{gen} = 330\ \Omega$                                                                               |     |      |     |                                      |
|                                   |                                                           | IFGAIN = 0                                                                                            | -   | 8    | 10  | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
|                                   |                                                           | IFGAIN = 1                                                                                            | -   | 6.5  | 10  | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $V_{I(IFAMP)}$                    | DC voltage IF amplifier input                             | FM mode                                                                                               | 2.2 | 2.7  | 3.2 | V                                    |
| $R_i$                             | input resistance                                          |                                                                                                       | 270 | 330  | 390 | $\Omega$                             |
| $C_i$                             | input capacitance                                         |                                                                                                       | -   | 5    | 7   | pF                                   |
| Output: pin FMIFAMPOUT            |                                                           |                                                                                                       |     |      |     |                                      |
| $V_{o(max)(p)}$                   | maximum output voltage (peak value)                       |                                                                                                       | 1.2 | 1.5  | -   | V                                    |
| $V_{O(IFAMP)}$                    | DC voltage IF amplifier output                            | FM mode                                                                                               | 3   | 3.5  | 4   | V                                    |

Table 33: Dynamic characteristics ...continued

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see Figure 8; all AC values are given in RMS; unless otherwise specified.

| Symbol                                                                    | Parameter                                                              | Conditions                                                               | Min | Typ  | Max | Unit                      |
|---------------------------------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------|-----|------|-----|---------------------------|
| R <sub>o</sub>                                                            | output resistance                                                      |                                                                          | 270 | 330  | 390 | Ω                         |
| C <sub>o</sub>                                                            | output capacitance                                                     |                                                                          | -   | 5    | 7   | pF                        |
| IBOC amplifier (IBOC = 1)                                                 |                                                                        |                                                                          |     |      |     |                           |
| G                                                                         | gain                                                                   |                                                                          | -   | 8    | -   | dB                        |
| IP3                                                                       | 3rd-order intermodulation                                              |                                                                          | -   | 123  | -   | dBμV                      |
| Inputs: pins IFAMPIN and IFAMPDEC                                         |                                                                        |                                                                          |     |      |     |                           |
| V <sub>i(n)(eq)</sub>                                                     | equivalent input noise voltage                                         | R <sub>gen</sub> = 330 Ω                                                 | -   | 5.2  | 10  | $\frac{nV}{\sqrt{Hz}}$    |
| V <sub>i(max)(p)</sub>                                                    | maximum input voltage (peak value)                                     | 1 dB compression point of FM IF amplifier output voltage                 | 420 | -    | -   | mV                        |
| FM IF AGC                                                                 |                                                                        |                                                                          |     |      |     |                           |
| G <sub>AGC</sub>                                                          | small signal AGC amplifier gain $\frac{V_{IFOUT}}{V_{FMIFIN-FMIFDEC}}$ | linear range: V <sub>FMIFIN-FMIFDEC</sub> = 25 μV to 1 mV; no AGC active | -   | 28.5 | -   | dB                        |
| ΔAGC                                                                      | AGC range                                                              |                                                                          | 59  | -    | -   | dB                        |
| IP3                                                                       | 3rd-order intermodulation                                              | V <sub>FMIFIN-FMIFDEC</sub> = 95 dBμV                                    | -   | 121  | -   | dBμV                      |
| t <sub>st</sub>                                                           | FM IF AGC settling time                                                | V <sub>FMIFIN</sub> = 1 mV to 10 mV                                      | -   | 2    | -   | ms                        |
|                                                                           |                                                                        | V <sub>FMIFIN</sub> = 10 mV to 1 mV                                      | -   | 1    | -   | ms                        |
| Inputs: pins FMIFIN and FMIFDEC                                           |                                                                        |                                                                          |     |      |     |                           |
| V <sub>i(IF)</sub>                                                        | IF input voltage for IF AGC start level                                | start of AGC                                                             | -   | 65   | -   | dBμV                      |
| V <sub>i(max)(p)</sub>                                                    | maximum input voltage (peak value)                                     |                                                                          | -   | 1.6  | -   | V                         |
| V <sub>i(n)(eq)</sub>                                                     | equivalent input noise voltage                                         | R <sub>gen</sub> = 330 Ω; no AGC active                                  | -   | 7    | -   | $\frac{nV}{\sqrt{Hz}}$    |
| R <sub>i</sub>                                                            | input resistance                                                       |                                                                          | 270 | 330  | 390 | Ω                         |
| C <sub>i</sub>                                                            | input capacitance                                                      |                                                                          | -   | 5    | 7   | pF                        |
| Output: pin IFOUT                                                         |                                                                        |                                                                          |     |      |     |                           |
| V <sub>O</sub>                                                            | FM IF output voltage                                                   | R <sub>L</sub> = 1 kΩ; AGC active                                        | 89  | 94   | 99  | dBμV                      |
| FM IF level detector output: pin VLEVEL; see <a href="#">Figure 5 [8]</a> |                                                                        |                                                                          |     |      |     |                           |
| V <sub>VLEVEL</sub>                                                       | DC output voltage                                                      | V <sub>i</sub> = 10 μV to 1 V                                            | 0   | -    | 5   | V                         |
|                                                                           |                                                                        | V <sub>i</sub> < 1 μV; standard setting of level DAA                     | 0.1 | 0.35 | 0.8 | V                         |
|                                                                           |                                                                        | V <sub>i</sub> = 1 mV; standard setting of level DAA                     | 1.4 | 2    | 2.4 | V                         |
| ΔV <sub>level</sub>                                                       | step size for adjustment of level starting point                       | LSL[2:0] = 100                                                           | 40  | 53   | 70  | mV                        |
| V <sub>level(slope)</sub>                                                 | slope of level voltage $\frac{\Delta V_{level}}{\Delta V_i}$           | V <sub>i</sub> = 1 mV to 300 mV; standard setting of level slope         | 0.8 | 1    | 1.2 | $\frac{V}{20 \text{ dB}}$ |

**Table 33: Dynamic characteristics ...continued**

$V_{AMMIX2OUT1} = V_{AMMIX2OUT2} = V_{MIX1OUT1} = V_{MIX1OUT2} = V_{DDA1} = V_{DDA2} = V_{DDA3} = V_{DDA4} = V_{DDA6} = 8.5 \text{ V}$ ;  $V_{DDA5} = 5 \text{ V}$ ;  
 $V_{DDD} = 5 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; see [Figure 8](#); all AC values are given in RMS; unless otherwise specified.

| Symbol                   | Parameter                                                    | Conditions                                                                           | Min | Typ | Max  | Unit                              |
|--------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------|-----|-----|------|-----------------------------------|
| $\Delta V_{\text{step}}$ | step size for adjustment of level slope                      | $V_i = 1 \text{ mV}$                                                                 | 55  | 75  | 95   | $\frac{\text{mV}}{20 \text{ dB}}$ |
| $B_{\text{level}}$       | bandwidth of level output voltage                            | $V_i = 10 \text{ mV}$ ; standard setting of level DAA                                | 200 | 300 | -    | kHz                               |
| $I_{\text{source}}$      | output source current                                        | $V_{\text{level(ref)}} - 60 \text{ mV}$ ; $V_i = 1 \text{ mV}$                       | -   | -   | -300 | $\mu\text{A}$                     |
| $I_{\text{sink}}$        | output sink current                                          | $V_{\text{level(ref)}} + 25 \text{ mV}$ ; $V_i = 1 \text{ mV}$                       | 50  | -   | -    | $\mu\text{A}$                     |
| $R_o$                    | output resistance                                            |                                                                                      | -   | -   | 500  | $\Omega$                          |
| RR                       | ripple rejection $\frac{V_{\text{VLEVEL}}}{V_{\text{DDA6}}}$ | $V_{\text{DDA6(ripple)}} = 100 \text{ mV}$ ;<br>$f_{\text{ripple}} = 100 \text{ Hz}$ | -   | 40  | -    | dB                                |

**FM IF/AM IF2 buffer**

Output: pin IFOUT

|                        |                                                  |  |   |   |     |            |
|------------------------|--------------------------------------------------|--|---|---|-----|------------|
| $Z_{\text{L(min)}}$    | minimum load impedance for IF multiplexer/buffer |  | 1 | - | -   | k $\Omega$ |
| $V_{\text{o(max)(p)}}$ | maximum output voltage (peak value)              |  | - | - | 750 | mV         |

**RDS update**Output: pin AFHOLD; see [Figure 6](#)

|                        |                      |                                                                           |   |     |     |    |
|------------------------|----------------------|---------------------------------------------------------------------------|---|-----|-----|----|
| $I_{\text{sink(max)}}$ | maximum sink current | after first bus transmission with $\text{AF} = 1$ ; $V_o = 0.5 \text{ V}$ | 1 | 1.2 | 1.4 | mA |
|------------------------|----------------------|---------------------------------------------------------------------------|---|-----|-----|----|

[1] Measured between pins XTAL1 and XTAL2.

[2] DAA conversion gain formula:  $V_{\text{DAAOUT}} = \left[ 2 \times \left( 0.75 \times \frac{n}{128} + 0.125 \right) \times (V_{\text{DAAIN}} + V_{\text{DAATD}}) \right] - V_{\text{DAATD}}$ ; where  
 $n = 0$  to 127.

[3]  $V_{\text{LSB}} = V_{\text{DAAOUT}(n+1)} - V_{\text{DAAOUT}(n)}$ 

[4] The AM AGC transconductance buffer delivers a sink current which is proportional to the voltage change at pin TRFAMAGC.

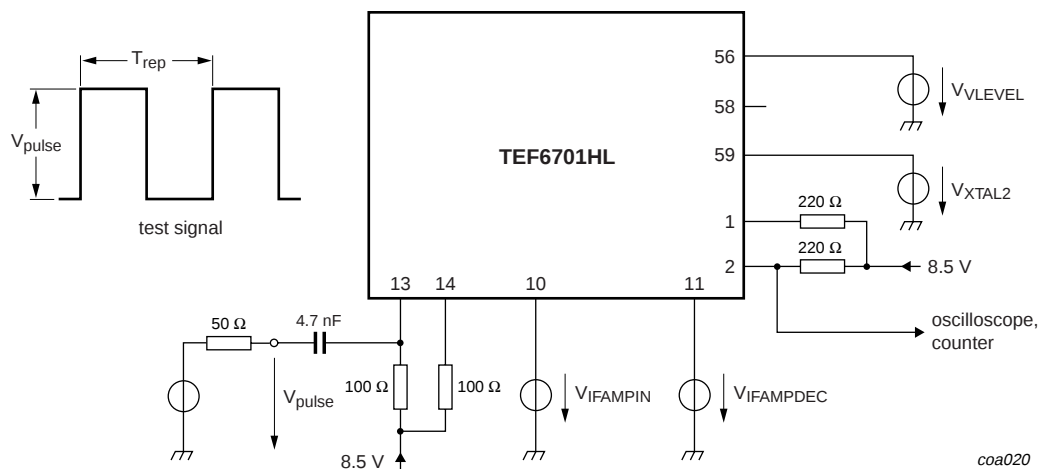
$$\Delta V_{\text{TRFAMAGC}} = V_{\text{TRFAMAGC}} - V_{\text{TRFAMAGC}} \Big|_{(V_{\text{AMMIX1IN}} - V_{\text{AMMIX1DEC}}) < 10 \text{ mV}}$$

[5] Input parameters of AM IF2 measured between pins AMIF2IN and AMIF2DEC.

[6] Image rejection ratio:  $\text{IRR} = \frac{V_{(\text{MIX1OUT1-MIX1OUT2})\text{wanted}}}{V_{(\text{MIX1OUT1-MIX1OUT2})\text{image}}}$

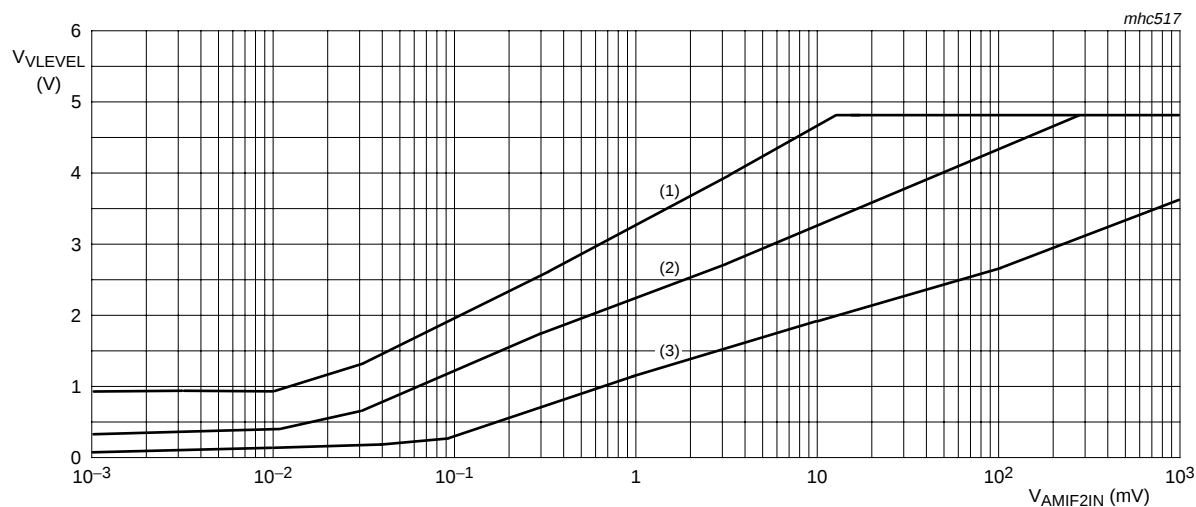
[7] Input parameters of FM IF amplifier measured between pins IFAMPIN and IFAMPDEC.

[8] Input parameters of FM IF level detector measured between pins FMIFIN and FMIFDEC.



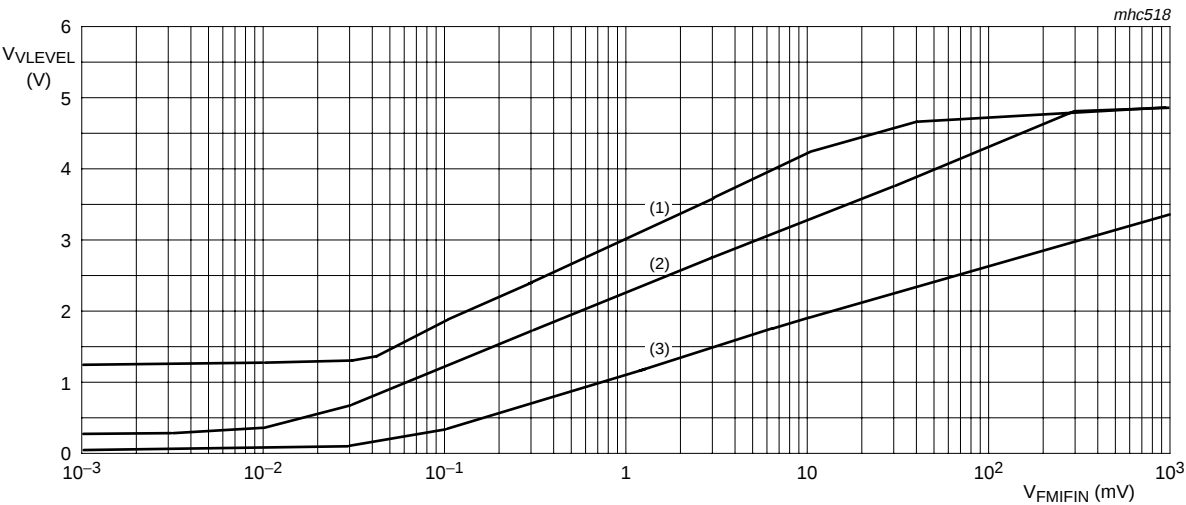
Test signal:  $T_{rep} = 2 \text{ ms}$ ,  $t_r < 50 \text{ ns}$ ,  $t_f < 50 \text{ ns}$  and duty factor 50 %.  
 $V_{XTAL2} = 3 \text{ V}$ ;  $V_{IFAMPIN} = 4 \text{ V}$  and  $V_{IFAMPIN-IFAMPDEC} = 0.2 \text{ V}$ .

Fig 3. Test circuit for AM noise blanker.



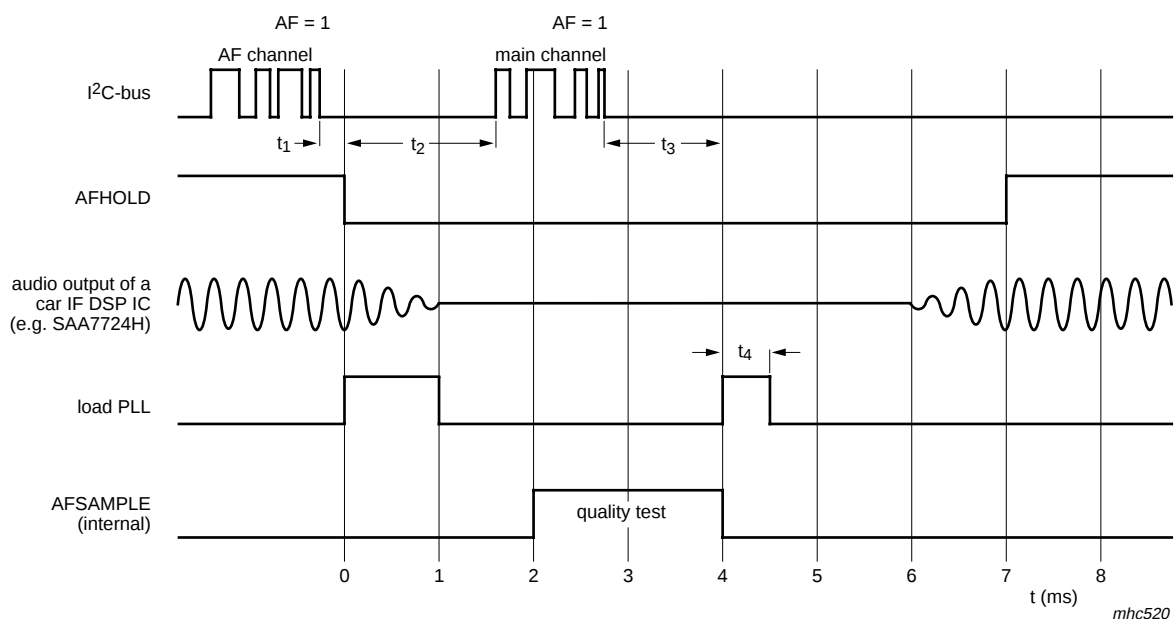
- (1) Level DAA setting byte 5 = FFH.
- (2) Level DAA setting byte 5 = 84H (standard setting).
- (3) Level DAA setting byte 5 = 00H.

Fig 4. AM level output voltage (DAA) as a function of AM level circuit input voltage.



- (1) Level DAA setting byte 5 = FFH.
- (2) Level DAA setting byte 5 = 84H (standard setting).
- (3) Level DAA setting byte 5 = 00H.

Fig 5. FM level output voltage (DAA) as a function of FM level circuit input voltage.



AFHOLD signal is used to hold the quality information for signal processing of the main channel during the alternative frequency jumps. PLL registers are loaded during load PLL = 1, but actual frequency jumps take place at the falling edge of this signal. IF counting is carried out during AFSAMPLE = 1. 10  $\mu$ s after falling edge of AFSAMPLE result is valid for AF and remains valid until read by microcontroller. Quality tests in a car IF DSP IC (e.g. SAA7724H) should take place 2 ms after falling edge of AFHOLD.

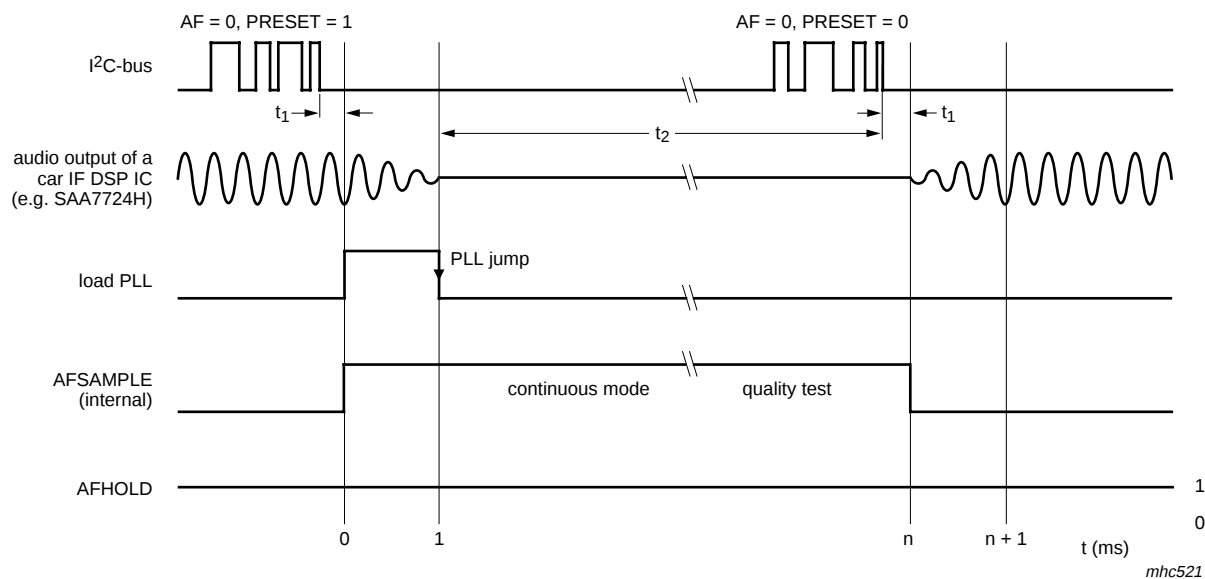
$t_1$  is the internal TEF6701HL clock related logic delay: 100  $\mu$ s.

$t_2$  should be > 1.1 ms to ensure correct loading of PLL for the main channel.

$t_3$  should be > 0 to ensure inaudible update.

$t_4$  = 500  $\mu$ s.

**Fig 6. Inaudible AF update timing diagram.**



t<sub>1</sub> is the internal TEF6701HL clock related logic delay: 100 μs.  
t<sub>2</sub> should be greater than the required PLL tuning time for the given band (FM: t<sub>2</sub> > 1 ms; AM: t<sub>2</sub> > 20 ms).

Fig 7. Preset mode timing diagram.

## 14. Application information



Table 34: List of components

| Symbol | Parameter                      | Type                    | Manufacturer |
|--------|--------------------------------|-------------------------|--------------|
| C1     | capacitor for VCO tuning       | 270 pF; type NP0        |              |
| L1     | 10.7 MHz IF coil               | P7 PSG P826RC 5134N=S   | TOKO         |
| L2     | 450 kHz IF coil                | P7PSGAE-5078D=S         | TOKO         |
| L3     | oscillator coil                | E543SNAS-02010          | TOKO         |
| L4     | FM image rejection             | 611SNS-1066Y            | TOKO         |
| L5     | FM input transformer           | 369INS-3076X            | TOKO         |
| L6     | FM antenna coil                | LQN1HR50; 215 nH        | MURATA       |
| L7     | PIN diode bias                 | LQN1HR21; 500 nH        | MURATA       |
| L8     | connection image reject        | wire 10 mm/printed coil |              |
| L9     | AM input                       | 388BN-1211Z             | TOKO         |
| D1     | double varicap diode           | BB207                   | Philips      |
| D2     | silicon PIN diode              | BAP70-02                | Philips      |
| D3     | silicon PIN diode              | BAP70-02                | Philips      |
| D4     | high-speed double diode        | BAV99                   | Philips      |
| D5     | AM PIN diode                   | BAQ806                  | Philips      |
| D6     | high-speed diode               | BAS16                   | Philips      |
| D7     | varicap diode                  | BB208                   | Philips      |
| T1     | N-channel junction FET         | BF862C                  | Philips      |
| T2     | NPN general purpose transistor | BC847C                  | Philips      |
| F1     | ceramic filter                 | 10.7 MHz                | MURATA       |
| F2     | ceramic filter                 | 10.7 MHz                | MURATA       |
| F3     | ceramic filter                 | 450 kHz                 | MURATA       |
|        | crystal 20.5 MHz               | LN-G102-587             | NDK          |



For list of components see [Table 34](#).

**Fig 9. Test circuit (continued in Figure 10).**

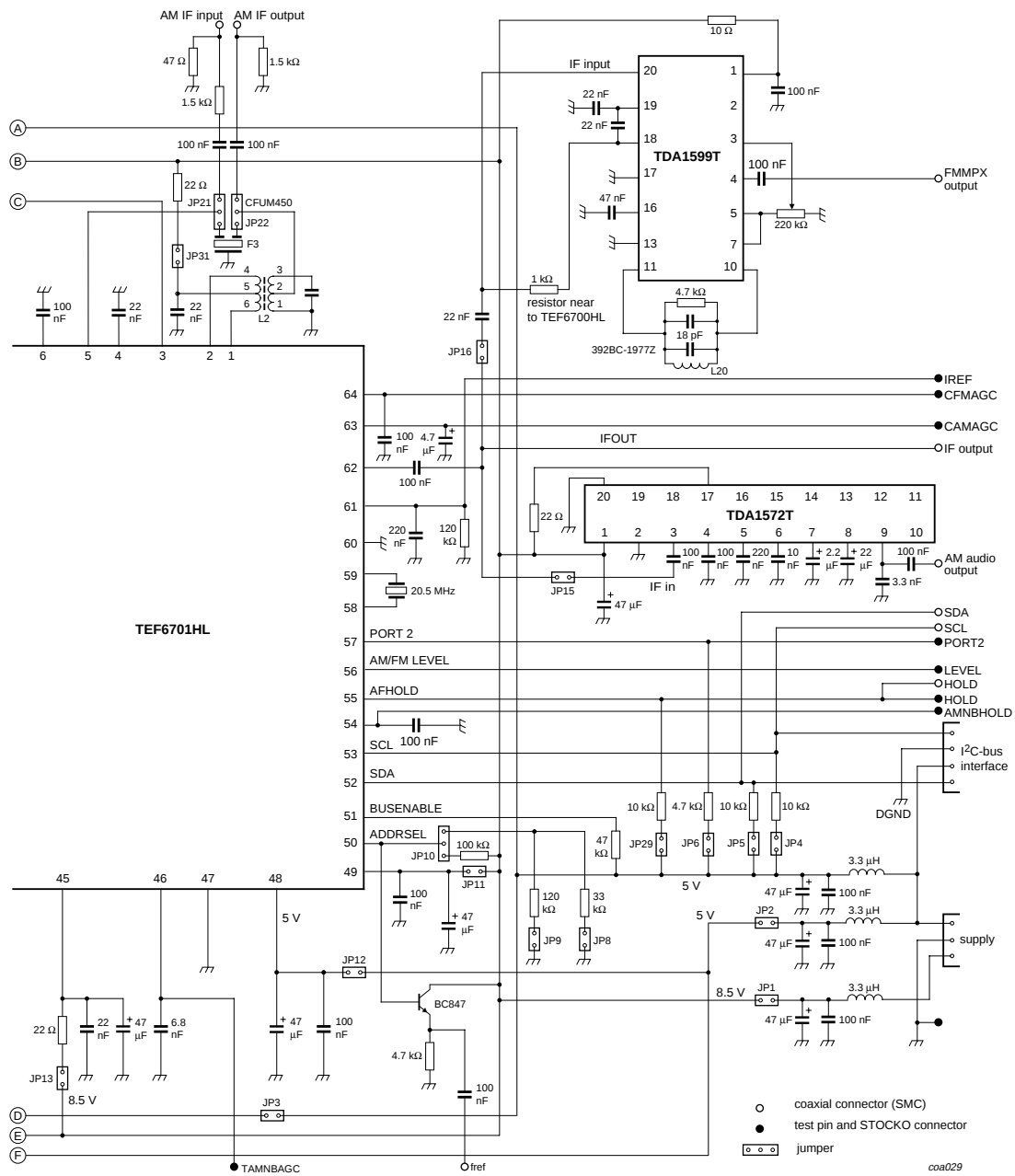


Fig 10. Test circuit (continued from Figure 9).

Table 35: DC operating points

| Symbol            | Pin | Unloaded DC voltage (V) |      |     |                        |             |                      |
|-------------------|-----|-------------------------|------|-----|------------------------|-------------|----------------------|
|                   |     | AM mode                 |      |     | FM mode                |             |                      |
|                   |     | Min                     | Typ  | Max | Min                    | Typ         | Max                  |
| AMMIX2OUT1        | 1   | external 8.5            |      |     | external 8.5           |             |                      |
| AMMIX2OUT2        | 2   | external 8.5            |      |     | external 8.5           |             |                      |
| FMIFIN            | 3   | -                       | 3.3  | -   | -                      | 3.3         | -                    |
| FMIFDEC           | 4   | -                       | 3.3  | -   | -                      | 3.3         | -                    |
| AMIF2IN           | 5   | -                       | 3    | -   | floating               |             |                      |
| AMIF2DEC          | 6   | -                       | 3    | -   | floating               |             |                      |
| i.c.              | 7   | -                       | 5.6  | -   | -                      | 5.6         | -                    |
| FMIFAMPOUT        | 8   | -                       | 8.1  | -   | -                      | 4           | -                    |
| V <sub>DDA1</sub> | 9   | external 8.5            |      |     | external 8.5           |             |                      |
| IFAMPIN           | 10  | -                       | 2.9  | -   | -                      | 2.7         | -                    |
| IFAMPDEC          | 11  | -                       | 2.9  | -   | -                      | 2.7         | -                    |
| IFAMPGND          | 12  | external 0              |      |     | external 0             |             |                      |
| MIX1OUT1          | 13  | external 8.5            |      |     | external 8.5           |             |                      |
| MIX1OUT2          | 14  | external 8.5            |      |     | external 8.5           |             |                      |
| V <sub>DDA2</sub> | 15  | external 8.5            |      |     | external 8.5           |             |                      |
| SWPORT1           | 16  | open-collector          |      |     | open-collector         |             |                      |
| AMMIX1DEC         | 17  | -                       | 2.8  | -   | floating               |             |                      |
| AMMIX1IN          | 18  | external biasing        |      |     | floating               |             |                      |
| VAMCAS            | 19  | -                       | 4.8  | -   | 0                      | 0.1         | 0.2                  |
| VAMCASFB          | 20  | -                       | 4.1  | -   | 0                      | 0.1         | 1                    |
| IAMAGC            | 21  | 7.1 (external biasing)  |      |     | external biasing       |             |                      |
| TAFAMAGC          | 22  | -                       | 0.3  | -   | 0 (no WB)              | 0.3 (no WB) | 0.5 (no WB)          |
| TRFAMAGC          | 23  | -                       | 2.9  | -   | floating               |             |                      |
| VREFFMMIX         | 24  | -                       | 3.2  | -   | -                      | 7.3         | -                    |
| FMMIXIN1          | 25  | -                       | 1.65 | -   | -                      | 2.75        | -                    |
| RFGND             | 26  | external 0              |      |     | external 0             |             |                      |
| i.c.              | 27  | external 0              |      |     | external 0             |             |                      |
| FMMIXIN2          | 28  | -                       | 1.65 | -   | -                      | 2.75        | -                    |
| WBFLAG            | 29  | 0                       |      |     | 4 (WB)                 | 4.5 (WB)    | 5 (WB)               |
|                   |     |                         |      |     | - (FM)                 | < 0.5 (FM)  | - (FM)               |
| IFMAGC            | 30  | 5 (external biasing)    |      |     | 0.1 (external biasing) | -           | 4 (external biasing) |
| AGCBUF            | 31  | 8.5 (external biasing)  |      |     | 8.5 (external biasing) |             |                      |
| DAAOUT            | 32  | -                       | 0.2  | 0.3 | 0.2                    | -           | 8.25                 |
| TKEYEDAGC         | 33  | floating                |      |     | 1                      | -           | 7                    |
| TFMAGC            | 34  | 7.8                     | 8.3  | 8.8 | -                      | 4           | -                    |
| DAATD             | 35  | floating                |      |     | 0.2                    | -           | 1.5                  |
| DAAIN             | 36  | 0                       | -    | 8.5 | 0                      | -           | 8.5                  |
| VTUNE             | 37  | 0                       | -    | 8.5 | 0                      | -           | 8.5                  |

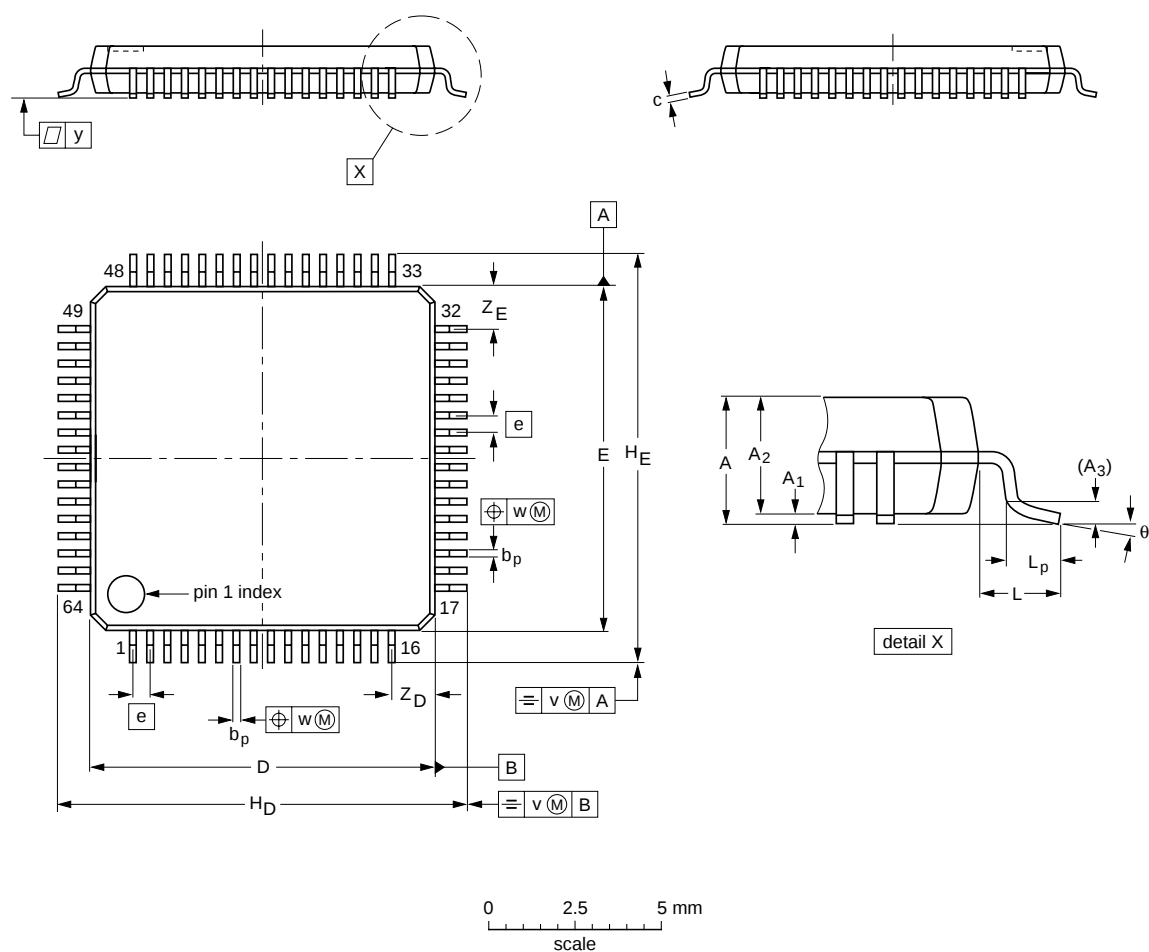
Table 35: DC operating points ...continued

| Symbol            | Pin | Unloaded DC voltage (V) |      |     |                  |      |     |
|-------------------|-----|-------------------------|------|-----|------------------|------|-----|
|                   |     | AM mode                 |      |     | FM mode          |      |     |
|                   |     | Min                     | Typ  | Max | Min              | Typ  | Max |
| CPOUT             | 38  | 0                       | -    | 8.5 | 0                | -    | 8.5 |
| V <sub>DDA3</sub> | 39  | external 8.5            |      |     | external 8.5     |      |     |
| DGND              | 40  | external 0              |      |     | external 0       |      |     |
| V <sub>DDD</sub>  | 41  | external 5              |      |     | external 5       |      |     |
| VCOGND            | 42  | external 0              |      |     | external 0       |      |     |
| OSCFDB            | 43  | 2.2                     | 2.8  | 3.4 | 2.2              | 2.8  | 3.4 |
| OSCTNK            | 44  | 5                       | 6.1  | 7.2 | 5                | 6.1  | 7.2 |
| V <sub>DDA4</sub> | 45  | external 8.5            |      |     | external 8.5     |      |     |
| TAMNBAGC          | 46  | -                       | 2.4  | -   | floating         |      |     |
| IFGND             | 47  | external 0              |      |     | external 0       |      |     |
| V <sub>DDA5</sub> | 48  | external 5              |      |     | external 5       |      |     |
| V <sub>DDA6</sub> | 49  | external 8.5            |      |     | external 8.5     |      |     |
| ADDRSEL           | 50  | -                       | 3.6  | -   | -                | 3.6  | -   |
| BUSENABLE         | 51  | external biasing        |      |     | external biasing |      |     |
| SDA               | 52  | external biasing        |      |     | external biasing |      |     |
| SCL               | 53  | external biasing        |      |     | external biasing |      |     |
| AMNBHOLD          | 54  | 4.3                     | 4.6  | 5.1 | 8                | 8.4  | -   |
| AFHOLD            | 55  | open-collector          |      |     | open-collector   |      |     |
| VLEVEL            | 56  | 0                       | -    | 5   | 0                | -    | 5   |
| SWPORT2           | 57  | open-collector          |      |     | open-collector   |      |     |
| XTAL1             | 58  | 1.7                     | 2.1  | 2.5 | 1.7              | 2.1  | 2.5 |
| XTAL2             | 59  | 1.7                     | 2.1  | 2.5 | 1.7              | 2.1  | 2.5 |
| XTALGND           | 60  | external 0              |      |     | external 0       |      |     |
| IREF              | 61  | 4                       | 4.25 | 4.5 | 4                | 4.25 | 4.5 |
| IFOUT             | 62  | -                       | 2.5  | -   | -                | 4.6  | -   |
| TAMIF2AGC         | 63  | -                       | 4    | -   | -                | 4.2  | -   |
| TFMIFAGC          | 64  | -                       | 5    | -   | -                | 4.8  | -   |

16. Package outline

LQFP64: plastic low profile quad flat package; 64 leads; body 10 x 10 x 1.4 mm

SOT314-2



| DIMENSIONS (mm are the original dimensions) |        |                |                |                |                |              |                  |                  |     |                |                |   |                |     |      |     |                               |                               |          |
|---------------------------------------------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|-----|----------------|----------------|---|----------------|-----|------|-----|-------------------------------|-------------------------------|----------|
| UNIT                                        | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c            | D <sup>(1)</sup> | E <sup>(1)</sup> | e   | H <sub>D</sub> | H <sub>E</sub> | L | L <sub>p</sub> | v   | w    | y   | Z <sub>D</sub> <sup>(1)</sup> | Z <sub>E</sub> <sup>(1)</sup> | θ        |
| mm                                          | 1.6    | 0.20<br>0.05   | 1.45<br>1.35   | 0.25           | 0.27<br>0.17   | 0.18<br>0.12 | 10.1<br>9.9      | 10.1<br>9.9      | 0.5 | 12.15<br>11.85 | 12.15<br>11.85 | 1 | 0.75<br>0.45   | 0.2 | 0.12 | 0.1 | 1.45<br>1.05                  | 1.45<br>1.05                  | 7°<br>0° |

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES |        |       |  | EUROPEAN PROJECTION                                                                   | ISSUE DATE           |
|-----------------|------------|--------|-------|--|---------------------------------------------------------------------------------------|----------------------|
|                 | IEC        | JEDEC  | JEITA |  |                                                                                       |                      |
| SOT314-2        | 136E10     | MS-026 |       |  |  | 00-01-19<br>03-02-25 |

Fig 11. Package outline SOT314-2 (LQFP64).

## 17. Soldering

### 17.1 Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *Data Handbook IC26; Integrated Circuit Packages* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

### 17.2 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 seconds and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 °C to 270 °C depending on solder paste material. The top-surface temperature of the packages should preferably be kept:

- below 225 °C (SnPb process) or below 245 °C (Pb-free process)
  - for all BGA, HTSSON..T and SSOP..T packages
  - for packages with a thickness  $\geq 2.5$  mm
  - for packages with a thickness  $< 2.5$  mm and a volume  $\geq 350$  mm<sup>3</sup> so called thick/large packages.
- below 240 °C (SnPb process) or below 260 °C (Pb-free process) for packages with a thickness  $< 2.5$  mm and a volume  $< 350$  mm<sup>3</sup> so called small/thin packages.

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

### 17.3 Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;

- smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time of the leads in the wave ranges from 3 seconds to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

## 17.4 Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 seconds to 5 seconds between 270 °C and 320 °C.

## 17.5 Package related soldering information

**Table 36: Suitability of surface mount IC packages for wave and reflow soldering methods**

| Package <sup>[1]</sup>                                                                         | Soldering method                   |                       |
|------------------------------------------------------------------------------------------------|------------------------------------|-----------------------|
|                                                                                                | Wave                               | Reflow <sup>[2]</sup> |
| BGA, HTSSON..T <sup>[3]</sup> , LBGA, LFBGA, SQFP, SSOP..T <sup>[3]</sup> , TFBGA, VFBGA, XSON | not suitable                       | suitable              |
| DHVQFN, HBCC, HBGA, HLQFP, HSO, HSOP, HSQFP, HSSON, HTQFP, HTSSOP, HVQFN, HVSON, SMS           | not suitable <sup>[4]</sup>        | suitable              |
| PLCC <sup>[5]</sup> , SO, SOJ                                                                  | suitable                           | suitable              |
| LQFP, QFP, TQFP                                                                                | not recommended <sup>[5] [6]</sup> | suitable              |
| SSOP, TSSOP, VSO, VSSOP                                                                        | not recommended <sup>[7]</sup>     | suitable              |
| CWQCCN..L <sup>[8]</sup> , PMFP <sup>[9]</sup> , WQCCN..L <sup>[8]</sup>                       | not suitable                       | not suitable          |

[1] For more detailed information on the BGA packages refer to the *(LF)BGA Application Note* (AN01026); order a copy from your Philips Semiconductors sales office.

[2] All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods*.

[3] These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding 217 °C ± 10 °C measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.

- [4] These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.
- [5] If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- [6] Wave soldering is suitable for LQFP, QFP and TQFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
- [7] Wave soldering is suitable for SSOP, TSSOP, VSO and VSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.
- [8] Image sensor packages in principle should not be soldered. They are mounted in sockets or delivered pre-mounted on flex foil. However, the image sensor package can be mounted by the client on a flex foil by using a hot bar soldering process. The appropriate soldering profile can be provided on request.
- [9] Hot bar soldering or manual soldering is suitable for PMFP packages.

18. Revision history

Table 37: Revision history

| Document ID | Release date | Data sheet status  | Change notice | Doc. number    | Supersedes |
|-------------|--------------|--------------------|---------------|----------------|------------|
| TEF6701HL_1 | 20041116     | Product data sheet | -             | 9397 750 13471 | -          |

## 19. Data sheet status

| Level | Data sheet status <sup>[1]</sup> | Product status <sup>[2] [3]</sup> | Definition                                                                                                                                                                                                                                                                                     |
|-------|----------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I     | Objective data                   | Development                       | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.                                                                                                    |
| II    | Preliminary data                 | Qualification                     | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.             |
| III   | Product data                     | Production                        | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN). |

[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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